BULLETIN 71

PENNSYLVANIAN CEPHALOPODS OF OHIO

DIVISION OF GEOLOGICAL SURVEY
4383 FOUNTAIN SQUARE DRIVE
COLUMBUS, OHIO 43224-1362
(614) 265-6576
(614) 447-1918 (FAX)
e-mail: geo.survey@dnr.state.oh.us
World Wide Web: http://www.dnr.state.oh.us/odnr/geo_survey/

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BULLETIN 71

PENNSYLVANIAN CEPHALOPODS OF OHIO

PART 1

NAUTILOID AND BACTRITOID CEPHALOPODS

by

Myron T. Sturgeon
Delbert L. Windle
Royal H. Mapes
and
Richard D. Hoare

PART 2

AMMONOID CEPHALOPODS

by
Royal H. Mapes
Delbert L. Windle
Myron T. Sturgeon
and
Richard D. Hoare

Columbus
1997

DIVISION OF GEOLOGICAL SURVEY

OHIO DEPARTMENT OF NATURAL RESOURCES

Composition and layout by Lisa Van Doren. Scanning and creation of some illustrations by Robert L. Stewart

Cover illustration: A reproduction of S. G. Morton's 1836 illustration of *Ammonites bellicosus*, the first nautiloid cephalopod named and described from the Pennsylvanian System in Ohio. Morton's specimens are now tentatively identified as *Latitemnocheilus bellicosus*; the location of his type material is unknown. See text, p. 49 and 51, and plate 1-16, figure 3, p. 128-129

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EDITOR'S NOTE

The authors turned in the manuscripts for this bulletin to the Division of Geological Survey in 1983. Several sessions of editing and revision took place through the 1980's. Publication of this bulletin was delayed because of budgetary cutbacks, staff changes, and other publication priorities of the Division of Geological Survey. Only minor updates have been made since the late 1980's.

The two parts are treated separately, except for the comprehensive glossary (Appendix C) and index. The book is continuously paged, but the chapters, figures, tables, and plates are numbered separately for each part as 1-1, 1-2, etc. and 2-1, 2-2, etc.

Merrianne Hackathorn
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BULLETIN 71

PENNSYLVANIAN CEPHALOPODS OF OHIO

PART 1

NAUTILOID AND BACTRITOID CEPHALOPODS

by

Myron T. Sturgeon
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Richard D. Hoare

Columbus
1997

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Chapter 1-1

INTRODUCTION

LOCATION AND EXTENT OF STUDY AREA

This bulletin concerns fossil cephalopods that are present in the marine units of the Pennsylvanian System in Ohio. With the exception of some examples from other areas for comparative, descriptive, and taxonomic purposes, all investigated specimens are from Ohio.

Marine units are exposed in all or parts of 33 counties in the eastern part of the state, extending from Lawrence County in the south to Lake County in the north (fig. 1-1). Ohio's Pennsylvanian rocks are on the western margin of the Northern Appalachian Basin.

PURPOSE AND SCOPE OF INVESTIGATION

The major purpose of this investigation is to identify fossil cephalopods and to determine their stratigraphic distribution in the Pennsylvanian System of Ohio. We hope this information will provide a broader base for the correlation of these stratigraphic units. Because the principal emphasis in this report is on identification, taxonomy, and biostratigraphy, and because most of the specimens were collected from waste piles in strip mines, paleoecologic interpretations are limited. However, the relationship between lithology of the source strata and the occurrence of specimens is generally recognized. Source strata are commonly calcareous shales and impure limestones that have a large content of clastic materials. Differences in relative abundance of nautiloids and ammonoids (see Part 2 of this bulletin) in Ohio and between the Appalachian and Midcontinent (primarily Arkansas, Kansas, Oklahoma, and Texas) regions warrant prudent consideration.

We hope that this information will add to our knowledge not only of the geographic and geologic occurrences of Pennsylvanian cephalopods, but also of their evolution. Continued collecting and observation will supplement the information given herein, and, when considered with data from other fossil groups, will make a more complete ecological interpretation possible.

METHOD OF INVESTIGATION

Pennsylvanian invertebrate fossils collected during a period of more than 40 years and stored at Ohio University form the basic materials for this investigation. These collections contain more than 2,500 nautiloids and ammonoids from 145 localities in the Pottsville, Allegheny, and Conemaugh Groups (see Appendix A). In a number of cases more than one collection was made from a particular locality.

This bulletin is divided into two parts. Part 1 deals with approximately 25 genera and 65 species of nautiloids and bactritoids. Part 2 (Mapes and others, 1997) deals with 17 genera and 25 species of ammonoids. As noted on page v, the manuscripts for this bulletin were completed in 1983.

For comparative purposes and taxonomic considerations, type and other pertinent specimens were borrowed from a number of institutions and individuals. Specimens previously collected and studied in Ohio were used where they were available. All specimens are incomplete and some are so poorly preserved that positive identification at the specific level was difficult or impossible.

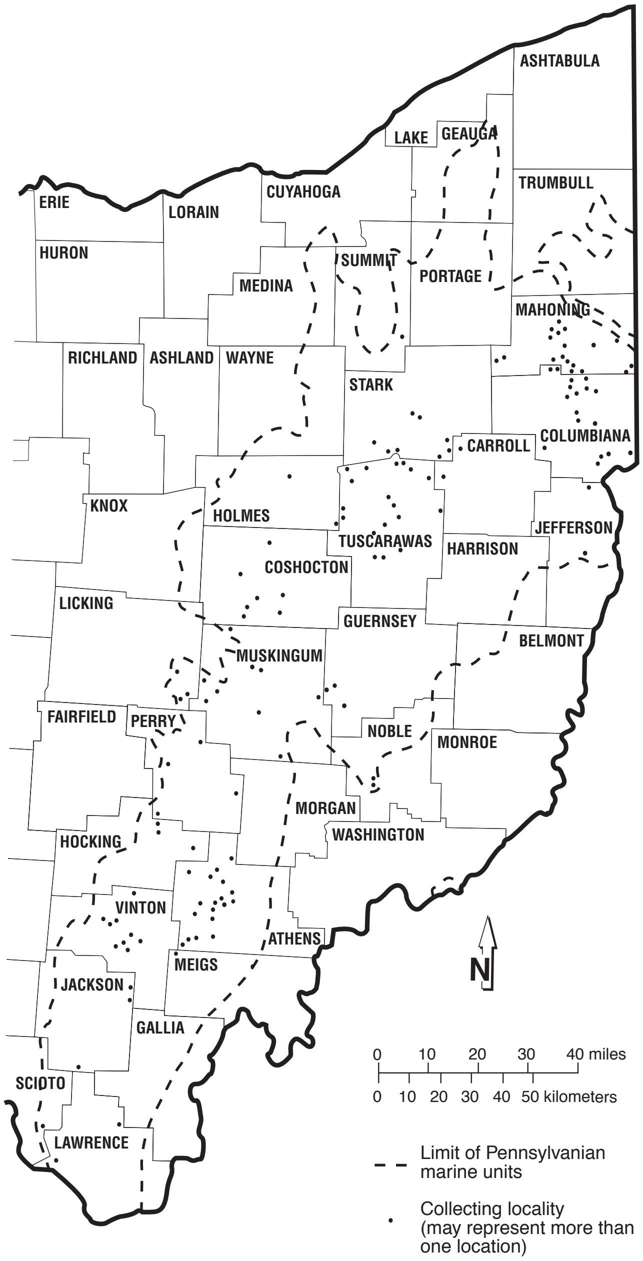


FIGURE 1-1.—Map of eastern Ohio showing collecting localities for Pennsylvanian nautiloid and bactritoid cephalopods.

Stratigraphic distribution of the available forms (table 1-2, p. 14-15) was compiled mainly on the basis of specimens in the collections under study for this report. Occurrences reported by previous investigators are included wherever they can be verified. Specimens from many previous fossil lists are no longer available and it is impossible to confirm their identifications. Differences in systematic nomenclature between present and former usage and differences in opinions on identifications can be inferred from the synonymies (see Chapter 1-4) and are discussed under the remarks for each taxon.

With exception of representatives already reposited in other institutions, all illustrated and pertinent specimens were placed in the repository of Orton Geological Museum at The Ohio State University. Some additional specimens are in the collections of Bowling Green State University and of Ohio University.

Stratigraphic occurrence and number of recognized specimens are recorded in table 1-3 (p. 16-17). An attempt was made to bring the taxonomy up to date when compiling the manuscript, but it has not been updated beyond the 1980's. In general, the suprageneric classification follows that of Teichert and others (1964). This hierarchy is outlined here:

- Subclass Nautiloidea Agassiz, 1847
  - Order Orthocerida Kuhn, 1940
    - Superfamily Orthocerataceae M'Coy, 1844
      - Family Orthceratidae M'Coy, 1844
        - Subfamily Michelinoceratinae Flower, 1945
          - Genus *Michelinoceras* Foerste, 1932
        - Subfamily Kionoceratinae Hyatt *in* Zittel, 1900
          - Genus *Thoracoceras* Fischer de Waldheim, 1844
      - Family Brachycycloceratidae Furnish, Glenister & Hansman, 1962 (proposed but unpublished amendment by Windle, 1973)
        - Genus *Brachycycloceras* Miller, Dunbar & Condra, 1933
    - Superfamily Pseudorthocerataceae Flower & Caster, 1935
      - Family Pseudorthoceratidae Flower & Caster, 1935
        - Subfamily Pseudorthoceratinae Flower & Caster, 1935
          - Genus *Pseudorthoceras* Girty, 1911
          - Genus *Mooreoceras* Miller, Dunbar & Condra, 1933
  - Order Oncocerida Flower *in* Flower & Kummel, 1950
    - Family Poterioceratidae Foord, 1888
      - Genus *Poterioceras* M'Coy, 1844
  - Order Nautilida Agassiz, 1847
    - Superfamily Tainocerataceae Hyatt, 1883
      - Family Tainoceratidae Hyatt, 1883
        - Genus *Tainoceras* Hyatt, 1883
        - Genus *Metacoceras* Hyatt, 1883
        - Genus *Parametacoceras* Miller & Owen, 1934
      - Family Koninckioceratidae Hyatt *in* Zittel, 1900
        - Genus *Endolobus* Meek & Worthen, 1865
      - Family Temnocheilidae Mojsisovics, 1902
        - Genus *Temnocheilus* M'Coy, 1844 (revised by Sturgeon, Windle, Mapes & Hoare, 1982)
        - Genus *Latitemnocheilus* Sturgeon, Windle, Mapes & Hoare, 1982
        - Genus *Mahoningoceras* Murphy, 1974
    - Superfamily Trigonocerataceae Hyatt, 1884
      - Family Trigonoceratidae Hyatt, 1884
        - Genus *Ungeroceras* Sturgeon & Miller, 1948
      - Family Grypoceratidae Hyatt *in* Zittel, 1900
        - Genus *Domatoceras* Hyatt, 1891
        - Genus *Stenodomatoceras* Ruzhencev & Shimansky, 1954
        - Genus *Stenopoceras* Hyatt, 1893
    - Superfamily Aipocerataceae Hyatt, 1883
      - Family Solenochilidae Hyatt, 1893
        - Genus *Solenochilus* Meek & Worthen, 1870
    - Superfamily Clydonautilaceae Hyatt *in* Zittel, 1900
      - Family Liroceratidae Miller & Youngquist, 1949
        - Genus *Liroceras* Teichert, 1940
        - Genus *Coelogasteroceras* Hyatt, 1893
        - Genus *Condraoceras* Miller, Lane & Unklesbay, 1947
      - Family Ephippioceratidae Miller & Youngquist, 1949
        - Genus *Ephippioceras* Hyatt, 1884
        - Genus *Megaglossoceras* Miller, Dunbar & Condra, 1933
- Subclass Bactritoidea Shimansky, 1951
  - Order Bactritida Shimansky, 1951
    - Family Bactritidae Hyatt, 1884
      - Genus *Ctenobactrites* Shimansky, 1951

TERMS, ABBREVIATIONS, AND REPOSITORIES

The following terms are used throughout this report on nautiloid cephalopods:

Orthoconic conchal diameters—small: <10 mm; medium: 10-30 mm; large: >30 mm.
Nautiliconic conchal diameters—small: <25 mm; small to medium: 25-50 mm; medium: 50-75 mm; medium to large: 75-100 mm; large: >100 mm.
Conchal parameters—D = maximum coiled conch diameter; H = maximum whorl height; W = maximum whorl width; U = maximum umbilical diameter; V = venter width.
Conchal shape—discoidal: W/D = <0.40; subdiscoidal: W/D = 0.40-0.60; subglobose: W/D = 0.60-0.80; globose: W/D = >0.80.
Whorl section—depressed: H/W = <0.90; equidimensional: H/W = 0.90-1.00; compressed: H/W = >1.00.
Umbilical diameter—narrow: U/D = <0.20; moderately narrow: U/D = 0.20-0.30; moderately wide: U/D = 0.30-0.40; wide: U/D = >0.40.
Test thickness—thin: <2 mm; medium: 2-4 mm; thick: >4 mm.

Figure 1-2 illustrates the general features of nautiloid cephalopod conchs. A glossary of morphological terms used for cephalopods is given in Appendix C. A few abbreviations are used in the chapter on systematic paleontology: OD = original designation; SD = subsequent designation; M = monotypy. Placement of the question mark indicates uncertainty in identification as follows: Assignment to genus uncertain—question mark immediately follows the genus name, as in *Thoracoceras*? sp. Genus correct, but assignment to species uncertain—question mark follows the species name, or the name(s) of the designator(s), as in *Pseudorthoceras seminolense* Girty?, 1911.

Repositories for specimens and their abbreviations are:

AMNH	American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024.
CM	Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, PA 15213.
CMNH	The Cleveland Museum of Natural History, 1 Wade Oval Drive, University Circle, Cleveland, OH 44106.
CWR	Department of Geological Sciences, Case Western Reserve University, Cleveland, OH 44106.
KU	Department of Geology, University of Kansas, Lawrence, KS 66045.
NMI	National Museum of Ireland, Dublin, Ireland.
OSU	Orton Geological Museum, Department of Geological Sciences, The Ohio State University, Columbus, OH 43210.
OU F	Department of Geological Sciences, Ohio University, Athens, OH 45701.
RSM	Royal Scottish Museum, Edinburgh, Scotland (JW,

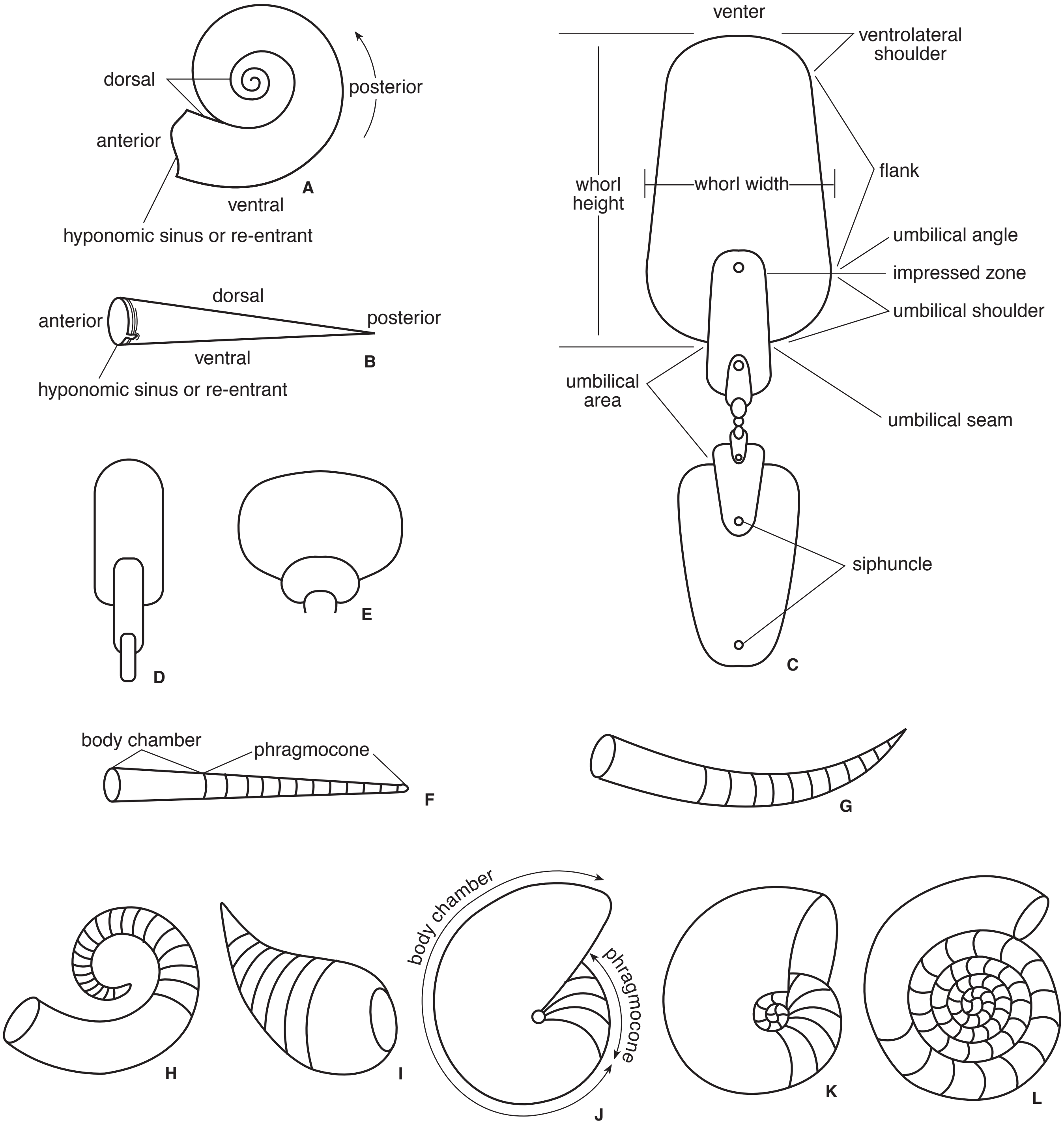


FIGURE 1-2.—General features, common shell forms, and coiling types of nautiloid conchs. Slightly modified from Teichert and others (1964, figs. 4, 5, 7).

A, orientation of a coiled conch.
B, orientation of a straight (orthoconic) conch.
C, diagrammatic cross section of a moderately evolute coiled conch illustrating various morphological features.
D, partial conchal cross section showing compressed whorls in a moderately evolute discoidal conch.
E, partial conchal cross section showing depressed whorls in a moderately evolute globose conch.
F, orthoconic conch showing body chamber and phragmocone.
G, cyrtoconic conch showing body chamber and phragmocone.
H, gyroconic conch showing body chamber and phragmocone.
I, breviconic conch showing body chamber and phragmocone.
J, involute coiled conch.
K, convolute coiled conch.
L, evolute coiled conch.

	James Wright collection).
SUI	Department of Geology, State University of Iowa, Iowa City, IA 52242.
UC (FMNH)	University of Chicago (Field Museum of Natural History), Roosevelt Road and Lake Shore Drive, Chicago, IL 60605.
UI	Department of Geology, University of Illinois, Urbana, IL 61801.
UM	Department of Geology, University of Missouri, Columbia, MO 65211.
UNSM	University of Nebraska State Museum, Department of Geology, University of Nebraska, Lincoln, NE 68508.
USNM	U.S. National Museum of Natural History, Smithsonian Institution, Washington, DC 20560.
YPM	Peabody Museum of Natural History, Yale University, 170 Whitney Avenue, New Haven, CT 06511.

PREVIOUS INVESTIGATIONS

Although a dozen persons have reported upon Pennsylvanian cephalopods from Ohio and have listed approximately 60 species in some 30 genera, no comprehensive systematic report including all available specimens has previously been published. Earlier reports deal with a few forms or only with those from specific stratigraphic units. The reported numbers of genera and species differ from the actual numbers of known genera and species because of misidentifications, changes in taxonomy, and synonyms.

Morton (1836) was the first to describe representatives of Ohio's Pennsylvanian cephalopods. He named, briefly described, and crudely figured specimens of *Ammonites* (now *Latitemnocheilus*) *bellicosus* from the Vanport unit at Putnam Hill in Zanesville (Muskingum County) and A. (now *Schistoceras*) *hildrethi* presumably from the Cambridge unit near Cambridge (Guernsey County). Meek (1871b) described *Orthoceras* (now *Ctenobactrites*) *isogramma*, probably from the Lower Mercer unit at Bald Knob near Newark (Licking County). Whitfield (1882, 1891, 1893) published repeated descriptions of two new species, *Nautilus* (now *Endolobus*) *ortoni* and *N.* (now *Mahoningoceras*) *subquadrangulare* from the Lower Mercer unit in Summit and Mahoning Counties, respectively. Herrick (1887) cited three nautiloids from the Lower Mercer unit on Flint Ridge in Licking County.

Mark (1910, 1911) recorded cephalopods from the Lower Mercer unit in Licking and Muskingum Counties and later (1912) identified, without descriptions or illustrations, eight nautiloid species from the Ames, Brush Creek, Cambridge, and Portersville units. Morningstar (1921, 1922) listed and briefly described 11 species of nautiloids from the Boggs, Harrison, Lowellville (Poverty Run), Lower Mercer, McArthur (Putnam Hill), Sharon, and Upper Mercer units. Laird (1937) listed, without descriptions or illustrations, two or three nautiloid species from the Portersville unit in Muskingum County. Sturgeon (1936, 1937, 1938, 1946) described and illustrated 23 nautiloid species from the Allegheny Group and one nautiloid species from the Pottsville Group. Sturgeon and Miller (1948) described and illustrated three species of nautiloids from the Allegheny and Conemaugh Groups. Miller and Unklesbay (1947) included two nautiloid species from Ohio in their report on Conemaugh cephalopods from western Pennsylvania. Frontz (1966) described and illustrated a new giant *Solenochilus* from the Cambridge unit. Murphy (1966, 1970, 1974) discussed the generic relationship of *Ungeroceras ungeri* Sturgeon & Miller. He described and illustrated several species and one new genus of nautiloids from the Allegheny, Conemaugh, and Pottsville Groups. Windle (1970) reported on 31 ammonoid and nautiloid species from the Conemaugh of Ohio and included several species from Maryland, Pennsylvania, and West Virginia. Sturgeon, Windle, Mapes, and Hoare (1982) summarized the new and revised cephalopod taxa that resulted from the preparation of this bulletin. Davis and Mapes (1996) provide an overview of Ohio cephalopods; the section on Pennsylvanian cephalopods is based on the work in this bulletin.

ACKNOWLEDGMENTS

We sincerely thank those persons who have assisted us in various manners on many occasions. The following persons, while at the institutions listed, made numerous specimens under their care available for comparative purposes and in some cases granted permission to photograph certain specimens: R. L. Batten, American Museum of Natural History; S. M. Bergström, F. F. Glaze, and L. A. McCullough, The Ohio State University; R. M. Bonem, C. C. Branson, P. K. Sutherland, and T. J. Turmelle, University of Oklahoma; J. J. Burke and P. A. Helwig, The Cleveland Museum of Natural History; J. L. Carter and A. Kollar, Carnegie Museum of Natural History; F. J. Collier and J. E. Merida, National Museum of Natural History; A. Griesemer, University of Nebraska State Museum; R. L. Kaesler and A. H. Kamb, University of Kansas; N. J. Knepper, Colorado School of Mines; V. Kohler, Museum of Comparative Zoology, Harvard University; J. S. Lawless, C. MacClintock, and D. R. Ryerson, Peabody Museum of Natural History, Yale University; M. H. Nitecki, Field Museum of Natural History; W. A. Rice, Mount Union College; S. M. Savin, F. G. Stehli, and B. Wardlaw, Case Western Reserve University; J. H. Stitt and A. G. Unklesbay, University of Missouri; D. D. Stone, Marietta College; H. L. Strimple, University of Iowa.

Individuals who have given specimens outright are acknowledged at appropriate places within the report. Several students were of inestimable help in collecting, preparing, cataloging, and photographing specimens. Particular mention is made for those who assisted in preparation and typing of the manuscript, including J. D. Barnhouse, G. W. Blackie, P. M. Dunn, M. C. Hansen, C. S. Lee, R. L. Lipp, L. M. Ruhman, M. S. Sims, J. T. Stephenson, T. E. Tomastik, J. A. Walker, and E. A. Wood. A. M. Kurlinski typed the final manuscript; J. P. Moore photographed the nautiloids; P. R. Murphy verified certain taxonomic terms; and the late J. S. Turner provided frequent advice and consultation. G. K. Mapes, Ohio University, helped in the editing of the manuscript and in the preparation of the index. The late J. M. Lesher, of the Division of Geological Survey, used an optical-character-recognition scanner to transfer an unmarked copy of the typewritten manuscript to computer files and revised the computer files to reflect the several layers of editing changes.

The Department of Geological Sciences, Ohio University, furnished equipment and space during preparation of the report. The Ohio University Research Committee provided financial support for some supplies and for cartographic and typing services. The Ohio University Fund, Inc., and the Faculty Research Committee at Bowling Green State University furnished partial financial support in the form of supplies and travel expenses. H. R. Collins, former State Geologist and Chief of the Division of Geological Survey, provided support and encouragement.

Chapter 1-2

STRATIGRAPHY

The following brief summary presents some of the pertinent aspects of the brackish-water and marine Pennsylvanian strata of eastern Ohio. The Pennsylvanian System is the major coal-bearing sequence in Ohio and thus is of great economic importance.

Brackish-water and marine fossils are known from approximately 25 units of the lower three stratigraphic groups (Pottsville, Allegheny and Conemaugh) of the Pennsylvanian System in Ohio. None are definitely known in the upper part of the Conemaugh Group or in the overlying Monongahela Group. Cross and Schemel (1956, p. 38) however, reported brackish-water fossils in Monongahela strata of West Virginia. Possible brackish-water fossils also have been found in the Washington Formation (Dunkard Group) of Pennsylvanian-Permian age in eastern Ohio.

Table 1-1 is modified from that part of Stout's (1947) generalized stratigraphic section for Ohio between the Harrison ironstone at the base of the Pennsylvanian System and the Skelley limestone high in the Conemaugh Group. These two units mark the lower and upper limits of known brackish- water and marine fossils in the Pennsylvanian strata of Ohio. Additions and changes to Stout's section include several new or revised stratigraphic names (see Murphy and Picking, 1967) and minor changes in lithologic descriptions published since Stout's work. This table is not intended to be a final revision of this part of the Pennsylvanian section exposed in Ohio. The stratigraphic nomenclature and correlations may not necessarily agree with current usage of the Ohio Division of Geological Survey.

The Pennsylvanian units bearing brackish-water and marine fossils are quite diverse in lithology. They range from calcareous limestones to shaly, flinty and/or ferruginous limestones; from flints to calcareous, shaly, and/or ferruginous flints; from black carbonaceous shales to gray, calcareous, and clayey and/or silty shales; and include even clay ironstones.

These fossiliferous beds are normally only a few inches to several feet thick, but several limestones are 15 to 20 feet (4.5 to 6 meters) or more thick; in places fossiliferous shales are 30 feet (9 meters) or more thick. The fossiliferous beds are distributed at more or less regular intervals through more than 700 feet (225 meters) of cyclic strata associated with the coals. Calculations derived mostly from the generalized geologic section of Ohio rocks (Bownocker and Dean, 1929; Stout, 1939, 1947; Stout and others, 1943) indicate that brackish-water and marine fossiliferous units have a total thickness of 63 feet (19 meters) and an average individual thickness of 30 inches (76 cm); the coals that normally overlie these units average roughly 20 feet (6 meters) apart. These data reveal also that brackish-water and marine beds constitute approximately 9 percent of the total thickness. Published reports (see References cited) disclose that the greater amount of this thickness is marine. It should be remembered that the above calculations are only averages. Actual field thicknesses may differ considerably for different portions of the section and at different geographic localities for the same parts of the section. Furthermore, thickness values for most brackish-water and marine units are undoubtedly too small. At many localities the limestones are overlain by a considerable thickness of fossiliferous shale; these fossiliferous shales have been overlooked in many places. Hence, many recorded stratigraphic sections do not show the complete thickness of the shales. It is likely that most fossil collections have been made from the limestones and from the more conspicuously fossiliferous shales adjacent to the limestones.

It was long ago recognized that in many areas Pennsylvanian strata were repeated vertically in a definite sequence. Stout (1931) described the Pennsylvanian cycles in Ohio. Weller (1930, p. 102) proposed the term cyclothem for a single succession, and many geologists have since used that term. Although the term is not used in this report, Sturgeon and associates (1958, p. 39-42) summarized some features and problems of the cyclothem concept.

TABLE 1-1.—*Stratigraphic section of the lower Conemaugh, Allegheny, and Pottsville Groups in Ohio*

Marine units are indicated by **BOLDFACE CAPITALS**, brackish-water units by MEDIUM CAPITALS. The stratigraphic names listed in this table are the traditional/historical names used for the Pennsylvanian units in Ohio. All units below group rank are considered to be informal.

Group	Unit	Description	Thickness	
			Ft	In
Conemaugh	**SKELLEY**	Limestone, fossiliferous, marine, local; bedded and similar to Ames limestone or nodular and ferruginous in shale		4
	Duquesne	Coal, shaly, thin, local Underclay, local Limestone, nodular, freshwater Redbed, calcareous, local	 1 1 6	1 6 8 0
	Lower Grafton	Shale and/or sandstone	11	0
	GAYSPORT	Limestone, nodular or bedded, sandy, fossiliferous, marine Shale and/or sandstone; locally fossiliferous marine shale	1 16	0 0
	AMES	Limestone, light-gray, semicrystalline, bedded, massive, fossiliferous, marine, persistent; interbedded with shale; in many places greenish or pinkish	1	6
	Ames	Coal, shaly, thin, local Underclay and clay shale, persistent; composition differing from place to place Shale and/or sandstone, persistent	 1 14	3 0 0
	Harlem	Coal, shaly, persistent Underclay, siliceous	1 2	0 0
	Rock Riffle	Limestone, nodular, freshwater, local	4	6
	Round Knob	Redbed, varicolored, calcareous	12	0
	Saltsburg	Shale and/or sandstone	11	0
	NOBLE	Limestone, gray, nodular, fossiliferous, marine, interbedded with fossiliferous, marine greenish-gray shale, very local	2	6
	Upper Bakerstown	Coal, local Underclay and clay shale	1 4	0 0
	Ewing	Limestone, gray to bluish-gray, ferruginous, nodular, nonmarine	1	0
	Cow Run	Shale and/or sandstone; sandstone locally massive	20	0
	PORTERSVILLE	Shale and limestone, gray to black, fossiliferous, marine; soft to ferruginous shale with dark nodular limestone	2	0
	Anderson	Coal, thin, persistent Underclay, calcareous, ferruginous, shaly, persistent	1 3	8 0
	Bloomfield	Limestone, gray, nodular, fossiliferous, nonmarine, local	1	6
	Bakerstown	Shale and/or sandstone; sandstone locally massive	19	0
	CAMBRIDGE	Limestone and shale, fossiliferous, marine, persistent; widely varied in color, composition, and lithology	4	0
	Wilgus	Coal, nonpersistent; locally mineable in southern Ohio Underclay, shaly, local	2 3	0 8
	Buffalo	Shale and/or sandstone; sandstone locally massive	23	0

TABLE 1-1.—*Stratigraphic section of the lower Conemaugh, Allegheny, and Pottsville Groups in Ohio*—Continued

Group	Unit	Description	Thickness	
			Ft	In
Conemaugh	**BRUSH CREEK**	Limestone and shale, fossiliferous, marine, persistent; north of Muskingum County, mostly black sandy shale with nodules and lenses of dark limestone; locally southward as two beds of cherty and ferruginous limestone	20	0
	Brush Creek	Coal, thin, local Underclay and clay shale, varicolored Shale and/or sandstone	 10 10	4 0 0
	MASON	Shale, dark, fossiliferous, marine, local	5	0
	Mason	Coal, local Underclay, local	 2	6 6
	Upper Mahoning	Redbed, varicolored, local Shale and/or sandstone; sandstone locally massive	12 10	0 0
	Mahoning	Coal (No. 7A), mostly thin; locally mineable in northeastern Ohio	1	0
	Thornton	Underclay, nonpersistent	5	0
	Lower Mahoning	Limestone, gray to bluish-gray, ferruginous, fossiliferous, nonmarine, nonpersistent; nodular and embedded in clay Redbed, varicolored, local Shale and/or sandstone; sandstone locally massive	2 9 25	0 0 0
Allegheny	(UNNAMED)	Shale, black, carbonaceous, fossiliferous, brackish-water, local		4
	Upper Freeport	Coal (No. 7), nonpersistent, locally thick and mineable Underclay and shale Limestone and marly shale, fossiliferous, nonmarine, local Shale and/or sandstone; with ferruginous zones	3 7 2 17	0 0 0 0
	Bolivar	Coal, thin, local Underclay, flint and plastic, rather persistent	 5	3 0
	Shawnee	Limestone, bedded or nodular, locally ferruginous, fossiliferous, nonmarine, local	1	3
	Bolivar	Shale and/or sandstone	12	0
	DORR RUN	Shale, dark-gray to black, carbonaceous, fossiliferous, marine, local	1	9
	Lower Freeport	Coal (No. 6A), patchy, locally thick and mineable Underclay Limestone, nodular, fossiliferous, nonmarine, local Shale and/or sandstone; sandstone locally thick	1 2 1 25	0 6 0 0
	Upper Kittanning	Coal, present in only a few places Underclay, local Shale and/or sandstone	1 10	0 10 0
	WASHINGTONVILLE	Shale, gray to black, carbonaceous, fossiliferous, marine, rather persistent; in east-central and northeastern Ohio only	4	0
	Middle Kittanning	Coal (No. 6), mineable, persistent Underclay, siliceous, persistent	4 3	0 6
	Leetonia	Limestone, bedded or nodular, fossiliferous, nonmarine, local		6
	Middle Kittanning	Shale and/or sandstone	10	0
	TUSCARAWAS	Shale, dark-gray, fossiliferous, marine, local	1	6

TABLE 1-1.—*Stratigraphic section of the lower Conemaugh, Allegheny, and Pottsville Groups in Ohio*—Continued

Group	Unit	Description	Thickness	
			Ft	In
Allegheny	Strasburg	Coal (No. 5A), thin, local		6
	Oak Hill	Underclay, flint and plastic, rather persistent	4	0
	Strasburg	Shale and/or sandstone	3	0
	COLUMBIANA	Shale and nodular limestone, gray, fossiliferous, marine, rather persistent; in east-central and northeastern Ohio only	4	0
	Lower Kittanning	Coal (No. 5), mineable, persistent	2	4
		Underclay, persistent	5	0
		Shale and/or sandstone, nonpersistent	3	0
	Lawrence	Coal, shaly, local		4
		Underclay, flint and plastic, persistent	6	0
		Shale and/or sandstone	8	2
	FERRIFEROUS	Ironstone, clay ironstone, and limonite, fossiliferous, marine, local		8
	VANPORT	Limestone, flint, and shale, fossiliferous, marine	6	0
	Scrubgrass	Coal, present in only a few places		6
		Shale and/or sandstone	5	0
	Clarion	Coal (No. 4A), patchy, locally mineable	4	0
		Underclay, flint and plastic	5	0
	Canary	Ironstone, nodular; in southern Ohio only, local		6
	Clarion	Shale and/or sandstone; sandstone locally massive	10	0
	Winters	Coal; in Jackson and Vinton Counties, local	1	0
		Underclay, generally absent	4	0
	ZALESKI	Flint and limestone, dark-gray to black, locally shaly or ferruginous, fossiliferous, marine; in Jackson and Vinton Counties, local	1	0
	Ogan	Coal; in Jackson and Vinton Counties, local	1	0
		Underclay; in Jackson and Vinton Counties, local	2	0
		Shale and/or sandstone	25	0
	PUTNAM HILL	Limestone and shale, gray, fossiliferous, marine, quite persistent; in southern and northeastern Ohio only	4	0
	Brookville	Coal (No. 4), persistent	4	0
		Underclay, plastic, persistent	4	0
	Homewood	Shale and/or sandstone; sandstone locally massive	10	0
Pottsville	Tionesta	Coal (No. 3B), thin, local	1	0
		Underclay, plastic, persistent	5	0
		Shale and/or sandstone; sandstone locally massive	24	0
	BIG RED BLOCK	Ironstone, blocky clay ironstone, and/or limonite, sparingly fossiliferous, marine, local		4
	UPPER MERCER	Limestone and/or flint and shale, dark-bluish-gray to black, fossiliferous, marine	1	8
	Bedford	Coal, patchy	1	0
		Underclay, siliceous	3	0
		Shale and/or sandstone	7	0

TABLE 1-1.—*Stratigraphic section of the lower Conemaugh, Allegheny, and Pottsville Groups in Ohio*—Continued

Group	Unit	Description	Thickness	
			Ft	In
Pottsville	**SAND BLOCK**	Ironstone, blocky or nodular, locally fossiliferous, marine; siliceous clay ironstone or limonite; in southern Ohio only, local		6
	(unnamed)	Shale and/or sandstone	3	6
	Upper Mercer	Coal (No. 3A), local	1	0
		Underclay, siliceous, plastic	3	0
		Shale and/or sandstone	11	0
	LOWER MERCER or **LITTLE RED BLOCK**	Ironstone, nodular clay ironstone, and limonite, sparingly fossiliferous, marine; in southern Ohio only, local		3
	(unnamed)	Shale, siliceous	1	9
	LOWER MERCER	Limestone and shale; dark-bluish-gray to black limestone and shaly limestone, locally ferruginous or siliceous; similarly colored shale, very fossiliferous, marine, very persistent	2	0
	Middle Mercer	Coal, thin, persistent		6
		Underclay, siliceous, plastic	3	6
		Shale and/or sandstone	5	0
	Flint Ridge	Coal, thin, local		6
		Underclay, flint and plastic	4	0
		Shale and/or sandstone	5	0
	BOGGS	Limestone, flint, ironstone, and/or shale, fossiliferous, marine, nonpersistent; in east-central and southern Ohio only		6
	Lower Mercer	Shale, siliceous	1	0
		Coal (No. 3), thin, persistent	1	0
		Underclay, siliceous	3	0
		Shale and/or sandstone; sandstone locally massive	23	0
	LOWELLVILLE or **POVERTY RUN**	Limestone, ironstone, and shale, dark-gray to black, fossiliferous, marine; limestone resistent; shale with ironstone nudules locally; in east-central and northeastern Ohio only, local	1	0
	Vandusen	Coal, thin, nonpersistent	1	0
		Underclay	2	0
		Shale and/or sandstone	17	0
	BEAR RUN	Shale and ironstone, fossiliferous, brackish-water(?); blue-gray shale and red or gray blackband ironstone; in southern Ohio only, local	2	0
	Bear Run	Coal, local	1	6
		Underclay, siliceous	3	0
	Massillon	Shale and/or sandstone; sandstone locally massive	24	0
	QUAKERTOWN	Shale, fossiliferous, brackish-water, local; no detailed descriptive or thickness data available		?
	Quakertown	Coal (No. 2), locally mineable	2	0
		Underclay, siliceous	5	0
		Shale and/or sandstone	12	0
	GUINEA FOWL	Ironstone, siliceous clay ironstone, and limonite, fossiliferous, brackish-water(?); in southern Ohio only, local		3

TABLE 1-1.—*Stratigraphic section of the lower Conemaugh, Allegheny, and Pottsville Groups in Ohio*—Continued

Group	Unit	Description	Thickness	
			Ft	In
Pottsville	(unnamed)	Shale, siliceous	5	9
	ANTHONY	Shale, dark, fossiliferous, brackish-water	1	0
	Anthony	Coal, thin, local		3
	Sciotoville	Undreclay, flint and plastic	4	0
	(unnamed)	Shale and/or sandstone	20	0
	SHARON	Ironstone and shale, buff to brown, siliceous, fossiliferous, marine; soft ironstone or dark-gray shale		3
	Sharon	Shale, siliceous Coal (No. 1), patchy, locally mineable Underclay, siliceous Shale, siliceous, nonpersistent Conglomerate and/or sandstone, local; locally 100 ft or more thick	4 3 2 5 10	0 0 0 0 0
	HARRISON	Ironstone, buff to red, limonitic, siliceous, coarse, fossiliferous, marine, local		6

Chapter 1-3

STRATIGRAPHIC DISTRIBUTION AND ABUNDANCE

Nautiloid and bactritoid cephalopods are much less abundant than brachiopods and some groups of mollusks in Pennsylvanian marine and brackish-water units of Ohio. Only about 2,600 specimens are available from 139 localities (Appendix A), compared to more than 30,000 brachiopods from 346 localities (Sturgeon and Hoare, 1968) and approximately 9,500 molluscan bivalves and rostroconchs from 258 localities (Hoare and others, 1979) in the Pottsville, Allegheny, and Conemaugh Groups. No accurate count has been compiled for gastropods, scaphopods, and polyplacophorans, but their total certainly exceeds the number of cephalopods by a large margin. Figure 1-1 shows the areal distribution from which nautiloid and bactritoid collections were made. Tables 1-2 and 1-3 present stratigraphic distributions and fossil abundance. A few pertinent out-of-state specimens are included in table 1-3. No marine units are known in upper Pennsylvanian and Permian strata of Ohio above the Skelley limestone and shale in the upper part of the Conemaugh Group. Fossils of possibly brackish-water origin have been found in the Washington Formation (Dunkard Group) of Pennsylvanian-Permian age.

Pennsylvanian nautiloid and bactritoid cephalopods are not good biostratigraphic indicators at this time for the following reasons: (1) scarcity of adequate and representative local and regional collections, (2) apparent unequal stratigraphic distribution, (3) deficiency in refinement of numerous genera and species, (4) lack of well-documented evolutionary series, and (5) few comprehensive reports describing faunas. At the generic level these cephalopods are generally long ranging; at the specific level much taxonomic work remains to be accomplished. For these reasons we have chosen to treat the Pennsylvanian nautiloid and bactritoid occurrences in Ohio as “index” fossils having an implied direct relationship of specimen abundance of various species in the marine units and stages. This approach really summarizes which species have been most commonly recovered from each marine unit. We are hopeful that this procedure will aid future fossil collectors in identifying the various marine units in Ohio. Development of a regional biostratigraphic zonation for the Pennsylvanian System based on these fossils must await a more complete and detailed treatment of the cephalopod-rich units in the Midcontinent.

LONG-RANGING GENERA AND SPECIES

Specimens of at least six species of nautiloid and bactritoid cephalopods that are long ranging have been collected throughout the marine units of the Pennsylvanian System in Ohio. Two of these, *Brachycycloceras* spp. and *Metacoceras* sp. #2, can be disregarded because of specific uncertainty. The remaining four species include *Pseudorthoceras knoxense* (1,321 specimens, 12 units, 58 localities), *Mooreoceras normale* (153 specimens, 8 units, 27 localities), *Liroceras liratum* (130 specimens, 7 units, 29 localities), and *Ephippioceras ferratum* (12 specimens, 5 units, 9 localities). These species are indicative only of Pennsylvanian age rather than of a particular part of that system in the state (tables 1-2 and 1-3).

POTTSVILLE AND POTTSVILLE-ALLEGHENY GROUPS

Pottsville cephalopods, represented by a total of 127 specimens distributed in 12 genera and 15 species, are less abundant than cephalopods in the Allegheny and Conemaugh Groups and occur mostly at several localities of the Lowellville (Poverty Run) and Lower Mercer units, which have 62 and 60 specimens, respectively. Only four species are restricted to Pottsville marine units: *Latitemnocheilus* sp. #2 (Lower Mercer, 3 specimens from 2 localities), *Mahoningoceras pottsvillense* (Lower Mercer, 1 specimen from 1 locality), *M. subquadrangulare* (Lower Mercer, 2 specimens from 1 locality); *Solenochilus peculiare* (Lowellville/Poverty Run and Lower Mercer, 3 specimens from 3 localities). At this time these species are too few in numbers to be useful index fossils.

Another six species are present in the Pottsville and Allegheny Groups. Five of the species—*Metacoceras perelegans*, *Endolobus ortoni*, *E.* cf. *E. forbesianus*, *Latitemnocheilus* cf. *L. johnsoni*, and *Domatoceras williamsi*—are represented by at least one specimen each in the Lower Mercer unit of the Pottsville Group. In addition, one specimen of *Latitemnocheilus* cf. *L. johnsoni* is from the Lowellville (Poverty Run) unit. The sixth species, *Ctenobactrites isogramma*, is represented by three specimens from the Lower Mercer unit and one specimen from the Upper Mercer unit. These six species also have from 1 to 13 specimens each in the Putnam Hill, Vanport, Columbiana, and Washingtonville units of the Allegheny Group and are more apt to be found in those units (table 1-3).

The six long-ranging species mentioned previously have been collected from all three groups and are likewise represented by a paucity of specimens in the Pottsville Group.

ALLEGHENY AND ALLEGHENY-CONEMAUGH GROUPS

The Allegheny Group has the largest number of restricted genera and species—11 (possibly 12) genera and 28 (possibly 29) species totaling 197 specimens. These taxa are listed below with source units and numbers of specimens:

Brachycycloceras longulum, Columbiana: 1
Brachycycloceras? cf. *B.*? *spectrum*, Vanport: 1
Condraoceras? sp., Vanport: 1
Domatoceras obsoletum, Columbiana: 8
Domatoceras oreskovichi, Putnam Hill: 30, Columbiana: 1, Washingtonville: 3
Domatoceras shepherdi, Columbiana: 3, Washingtonville: 3
Latitemnocheilus bellicosus Vanport: 2

Latitemnocheilus medioventralis, Columbiana: 1
Latitemnocheilus cf. *L. harneri*, Putnam Hill: 6
Latitemnocheilus cf. *L. latus*, Putnam Hill: 2
Latitemnocheilus? sp. #1, Washingtonville: 2
Metacoceras lambi, Columbiana: 1
Metacoceras mutabile, Putnam Hill: 8
Metacoceras tricarinatum tricarinatum, Putnam Hill: 8, Vanport: 1
Metacoceras tricarinatum parvinodosum, Putnam Hill: 11
Metacoceras sp. #3, Vanport: 1
Metacoceras spp., Dorr Run: 1
Michelinoceras? *unicamera*, Putnam Hill: 11, Columbiana: 1
Parametacoceras cf. *P. bellatulum*, Putnam Hill: 2
Poterioceras subellipticum, Vanport: 1
Solenochilus bognari, Vanport: 1
Solenochilus greenensis, Columbiana: 9, Washingtonville: 1
Solenochilus millhorni, Putnam Hill: 5
Solenochilus cf. *S. springeri*, Putnam Hill: 8
Solenochilus sp., Washingtonville: 1
Temnocheilus annulonodosus, Putnam Hill: 25, Vanport: 3, Columbiana: 15, Washingtonville: 2
Temnocheilus quinqueliratus, Putnam Hill: 1, Vanport: 1
Ungeroceras ungeri, Putnam Hill: 13, Columbiana: 1
Genus indeterminate #1 sp., Putnam Hill: 1

Sixteen of the above species are represented by only one or two specimens each and hence seemingly have little potential for stratigraphic identification and correlation purposes. The most promising of the other species for these purposes are: *Michelinoceras*? *unicamera* in the Putnam Hill and Columbiana units; *Metacoceras mutabile* in the Putnam Hill unit; *M. tricarinatum tricarinatum* and *M. tricarinatum parvinodosum* in the Putnam Hill and Vanport units; *Temnocheilus annulonodosus* in the Putnam Hill, Vanport, Columbiana, and Washingtonville units; *Latitemnocheilus* cf. *L. harneri* in the Putnam Hill unit; *Ungeroceras ungeri* in the Putnam Hill and Columbiana units; *Domatoceras obsoletum* and *D. shepherdi* in the Columbiana and Washingtonville units; *D. oreskovichi* in the Putnam Hill, Columbiana, and Washingtonville units; *Solenochilus greenensis* in the Columbiana and Washingtonville units and *S. millhorni* and *Solenochilus* cf. *S. springeri* in the Putnam Hill unit. On the basis of available collections, the Putnam Hill unit has the largest number of distinctive species, including *Metacoceras mutabile, M. tricarinatum tricarinatum, M. tricarinatum parvinodosum, Temnocheilus annulonodosus, Latitemnocheilus* cf. *L. harneri, Ungeroceras ungeri, Domatoceras oreskovichi, Solenochilus millhorni,* and *Solenochilus* cf. *S. springeri*. *Domatoceras obsoletum* is known only from the Columbiana unit, and *D. shepherdi* and *S. greenensis* appear to be limited to the Columbiana and Washingtonville units. *Temnocheilus annulonodosus* is the most abundant species. For purposes of marine-unit recognition, real usefulness of several species is limited either by their paucity or by their abundance at only one or a few localities.

Another six (possibly seven) species in five (possibly six) genera have been collected only from the Allegheny and Conemaugh Groups. These taxa are:

Megaglossoceras spp., Putnam Hill: 1, Vanport: 1, Brush Creek: 3
Metacoceras clinocostatum, Putnam Hill: 4, Vanport: 1, Brush Creek: 114, Cambridge: 1
Metacoceras latum, Columbiana: 11, Washingtonville: 67, Brush Creek: 1
Mooreoceras tuba, Washingtonville: 9, Brush Creek: 1, Ames: 1
Poterioceras curtum, Putnam Hill: 9, Vanport: 1, Columbiana: 4, Washingtonville: 1, Brush Creek: 1
Thoracoceras? sp., Putnam Hill: 1, Brush Creek: 3
Genus indeterminate #2 sp., Putnam Hill: 1, Brush Creek: 1

Even these species are more indicative of the Allegheny Group and the lower Conemaugh Group, as only two are known above the Brush Creek unit. The total number of specimens is 237 individuals. Two species, *Metacoceras clinocostatum* (120 specimens) and *M. latum* (79 specimens) are relatively abundant and are most useful in recognition of units from the base of the Allegheny Group to the top of the Brush Creek unit in the lower Conemaugh Group. All other species, although they have many fewer specimens, have similar ranges. An exception may be *Mooreoceras tuba*, which has one doubtful individual above the Brush Creek unit; this species appears to be more diagnostic of the Washingtonville unit. The six long-ranging species listed above are most abundant in the Allegheny and Conemaugh marine units (table 1-3).

CONEMAUGH GROUP

The Conemaugh Group has the largest number of specimens restricted to a stratigraphic group. More than 436 individuals are distributed in eight genera and 15 species:

Coelogasteroceras dubium, Brush Creek: 1
Condraoceras primum, Cambridge: 1
Domatoceras cf. *D. highlandense*, Brush Creek: 1, Cambridge: 1, Ames: 3
Domatoceras spp., Brush Creek: 1, Ames: 1+
Metacoceras mcchesneyi, Brush Creek: 335+, Cambridge: 1, Portersville: 4, Ames: 1
Metacoceras cf. *M. mcchesneyi*, Ames: 1
Solenochilus cambridgensis, Cambridge: 4
Solenochilus johnstoni, Brush Creek: 3, Cambridge: 1
Solenochilus mcfarlandi, Brush Creek: 12
Stenodomatoceras gardi, Brush Creek: 45, Cambridge: 1
Stenopoceras smithi, Ames: 2
Tainoceras collinsi, Ames: 4
Tainoceras marylandicum, Ames: 9
Tainoceras sp. #1, Ames: 1
Tainoceras sp. #2, Ames: 3

A number of species, including *Tainoceras collinsi, T. marylandicum, Stenopoceras smithi*, and several unidentified species, appear to be restricted to the Ames unit, but their usefulness is limited by too few specimens. Similar limitation pertains to *Coelogasteroceras dubium* in the Brush Creek unit, to *Condraoceras primum* in the Cambridge unit, to *Solenochilus johnstoni* in those two units, and to *Domatoceras* cf. *D. highlandense* in the Brush Creek, Cambridge, and Ames units. *Metacoceras mcchesneyi* is represented by more than 340 specimens in several Conemaugh marine units—335+ specimens in the Brush Creek unit and six specimens from the Ames (1), Cambridge (1), and Portersville (4) units. More than 300 of the specimens from the Brush Creek unit are from a thanatocoenose at locality Cma-3. A similar ratio exists for *Stenodomatoceras gardi*—44 specimens are from locality Cma-3 and only two specimens are from two other localities. *Metacoceras mcchesneyi* and *Stenodomatoceras gardi* are not useful index fossils because almost all the specimens are from a single thanatocoenose. Hence, all the above species are seriously limited for index purposes.

SUMMARY OF SPECIMENS BY STRATIGRAPHIC UNIT AND LOCALITY

Forty-seven species (70 percent) of the total number of Pennsylvanian cephalopods from Ohio are represented in our collections by fewer than 10 specimens each. Those with one to four specimens (52 percent) total 35 species, and those with five to nine specimens (18 percent) total 12 species. The most abundant species is *Pseudorthoceras knoxense*, represented by 1,321 specimens, or roughly half the total number of specimens. *Metacoceras mcchesneyi*, the next most abundant species, has more than 340 specimens. Other species represented by more than 100 specimens are *Mooreoceras normale* (153 specimens), *Liroceras liratum* (130 specimens), and *Metacoceras clinocostatum* (120 specimens). Only *Metacoceras latum* (79 specimens) is in the range of 50 to 100 specimens. Four species have between 25 and 49 specimens: *Brachycycloceras* spp. (45 specimens), *Stenodomatoceras gardi* (46), *Temnocheilus annulonodosus* (45), and *Metacoceras perelegans* (25). Species represented by 10 to 24 specimens each include *Poterioceras curtum* (16), *Ungeroceras ungeri* (14), *Ctenobactrites isogramma* (13), *Ephippioceras ferratum* (12), *Michelinoceras*? *unicamera* (12), *Solenochilus mcfarlandi* (12), *Metacoceras tricarinatum parvinodosum* (11), *Mooreoceras tuba* (10), *Metacoceras* sp. #2 (10), and *Solenochilus greenensis* (10). Table 1-3 provides information on abundances and ranges.

The total number of cephalopod specimens in the various stratigraphic units ranges from none in such beds as the Boggs, Mason, Noble, and Skelley marine units to over 900 specimens in the Putnam Hill (951) and Brush Creek (942) units (see table 1-3). No cephalopods have been collected from units considered to be brackish water in the Pottsville Group or from the unnamed shale overlying the Upper Freeport coal at top of the Allegheny Group. The total number of specimens per unit for the other units is: Columbiana (195), Washingtonville (180), Vanport (82), Cambridge (76), Lowellville (Poverty Run) (67), Lower Mercer (60), Ames (21+), Portersville (21), Gaysport (6), Upper Mercer (4), Dorr Run (1), Sharon (1), and Zaleski (1).

The following 21 collecting localities (see Appendix A for descriptions) have yielded five or more species each; the number of specimens ranges from six to more than 570:

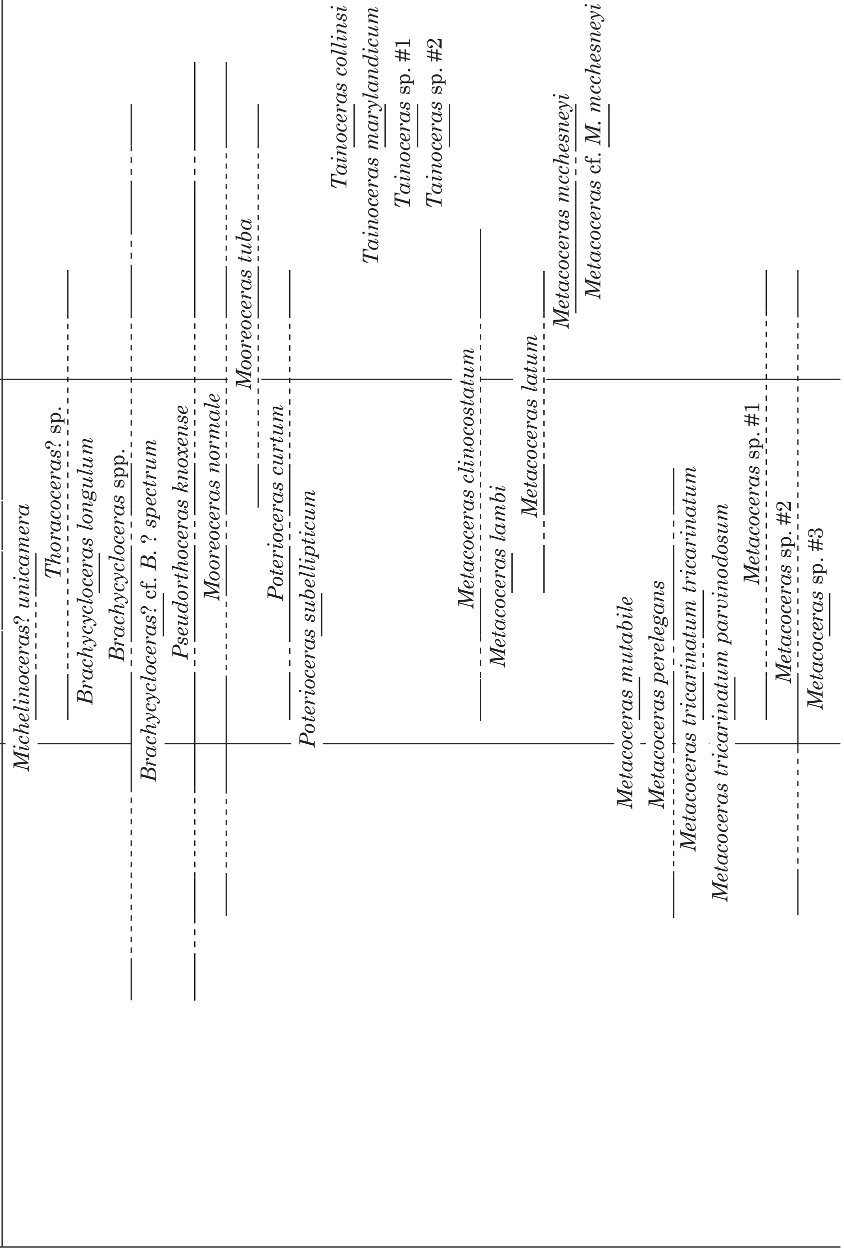
Aa-41, 12 species (296 specimens);
CAr-2, 9 species (95 specimens);
Cma-3, 11 species (572+ specimens);
Cp-3, 7 species (30 specimens);
Cs-3, 5 species (9 specimens);
Hw-16, 4 species (135 specimens);
Ls-1, 5 species (61 specimens);
Mc-1, 6 species (14 specimens);
Mg-2, 12 species (51 specimens);
Mg-3, 5 species (37 specimens);
Mg-4, 8 species (42 specimens);
Mg-7, 6 species (20 specimens);
Mg-10, 6 species (15 specimens);
Ms-3, 20 species (180 specimens);
MUmu-1, 6 species (22 specimens);
MUu-2, 6 species (8 specimens);
Td-4, 8 species (29 specimens);
Tl-1, 6 species (6 specimens);
Ty-3, 11 species (142 specimens);
Vel-15, 15 species (109 specimens);
Vel-19, 5 species (26 specimens).

Significant factors limiting the number of available specimens include: (1) size of exposure, (2) length of time exposed, (3) abundance of specimens, (4) number of times collected and number of collectors, and (5) aptitude and experience of collectors. Locality Ms-3 includes strip mines distributed over several square miles. Locality Aa-41 has been exposed for decades and collected many times. Localities CAr-2, Cma-3, Mg-4, Ms-3, Ty-3, and Vel-15 are examples of localities that have abundant fossils. Localities Td-4, Ty-3, and Vel-15 are examples of localities that have been collected a number of times by numerous individuals. These localities are only the prime examples of the above factors. No accurate record of number of visits to most localities is available.

TABLE 1-2.—*Stratigraphic distribution*[1] *of Pennsylvanian*

Group	Marine/brackish-water units[2]
Conemaugh	Skelley limestone and shale
	Gaysport limestone and shale
	Ames limestone and shale
	Noble limestone and shale
	Portersville shale and limestone
	Cambridge limestone and shale
	Brush Creek limestone and shale
	Mason shale
Allegheny	unnamed shale
	Dorr Run shale
	Washington shale
	Tuscarawas shale
	Columbiana shale and limestone
	Vanport limestone, flint, and shale
	Zaleski flint, limestone, and shale
	Putnam Hill limestone and shale
Pottsville	Upper Mercer limestone, flint, and shale
	Sand Block ironstone
	Lower Mercer ironstone
	Lower Mercer limestone and shale
	Boggs limestone, flint, and shale
	Lowellville (Poverty Run) limestone and shale
	Bear Run shale
	Quakertown shale
	Anthony shale
	Sharon ironstone and shale
	Harrison ironstone

Species



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[1] Dashed lines indicate inferred distribution.

[2] The stratigraphic names in this table are the traditional/historical names used for the Pennsylvanian units in Ohio.

nautiloid and bactritoid cephalopods in Ohio

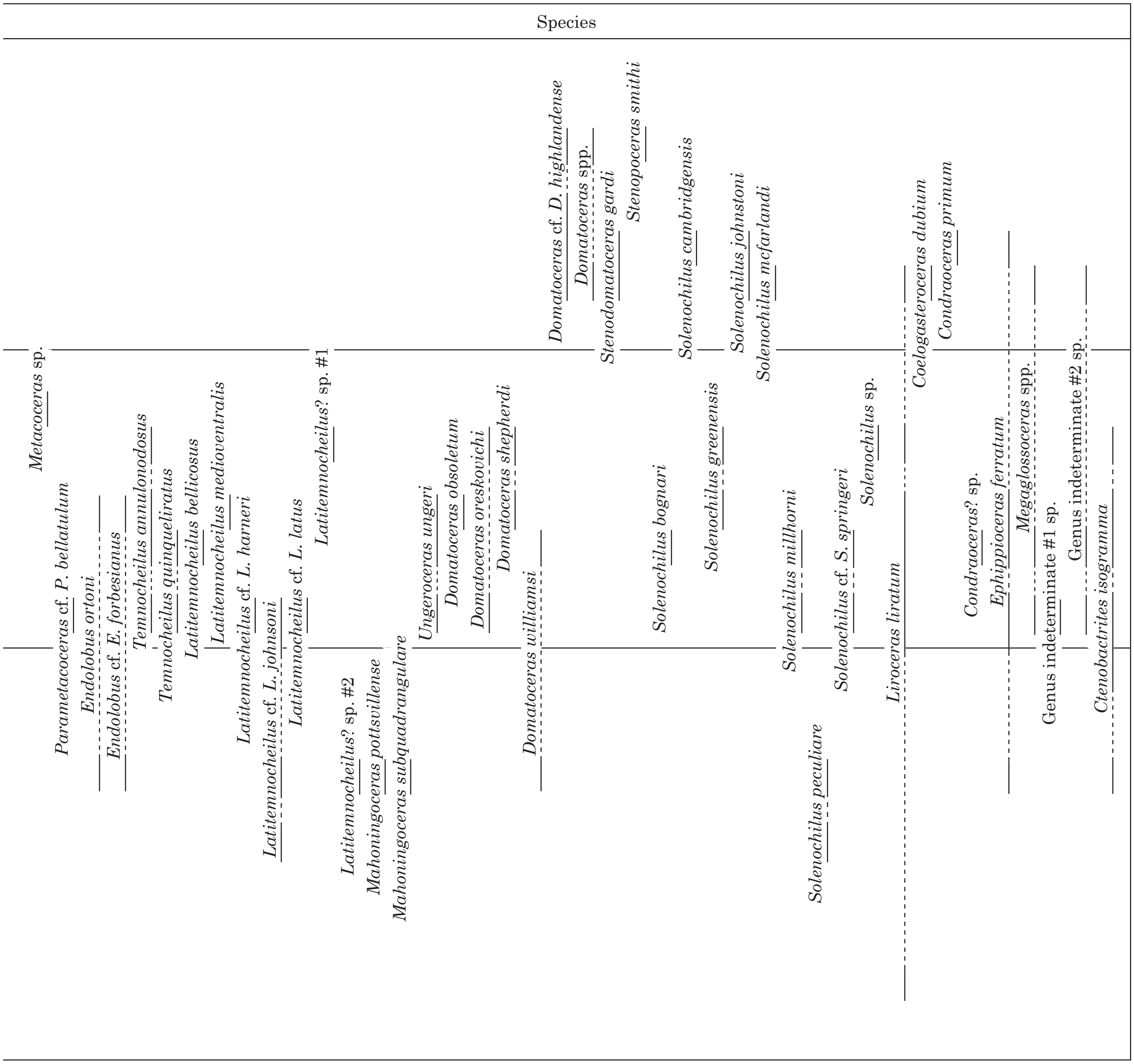

TABLE 1-3.—*Abundance, by stratigraphic unit, of Pennsylvanian nautitloid and bactritoid cephalopods in Ohio*

Species	Stratigraphic unit[1]															Total number of Ohio specimens	Number of additional out-of-state specimens
	Pottsville Group				Allegheny Group						Conemaugh Group						
	Sharon	Lowellville	Lower Mercer	Upper Mercer	Putnam Hill	Zaleski	Vanport	Columbiana	Washingtonville	Dorr Run	Brush Creek	Cambridge	Portersville	Ames	Gaysport		
Michelinoceras? *unicamera*					11			1								12	
Thoracoceras? sp.					1						3					4	
Brachycycloceras longulum								1								1	
Brachycycloceras spp.		1		1	17		6	9	1		7		2	1		45	
Brachycycloceras? cf. *B.*? *spectrum*							1									1	
Pseudorthoceras knoxense		59	35	1	745[2]		33	35	73		253	65	15	2	5	1,321	
Mooreoceras normale			1	1	17			33	9		89			2	1	153	
Mooreoceras tuba									9		1					10	1
Poterioceras curtum					9		1	4	1		1					16	
Poterioceras subellipticum							1									1	1
Tainoceras collinsi														2		2	2
Tainoceras marylandicum														2		2	7
Tainoceras sp. #1														1		1	
Tainoceras sp. #2														3		3	
Metacoceras clinocostatum					4		1				114	1				120	
Metacoceras lambi								1								1	
Metacoceras latum								11	67		1					79	
Metacoceras mcchesneyi											335+	1	4	1		341+[3]	
Metacoceras cf. *M. mcchesneyi*														1		1	
Metacoceras mutabile					8											8	
Metacoceras perelegans			1		6		4	13	1							25	
Metacoceras tricarinatum tricarinatum					8		1									9	
Metacoceras tricarinatum parvinodusum					11											11	
Metacoceras sp.#1					1						5					6	
Metacoceras sp.#2			6		3						1					10	
Metacoceras sp. #3							1									1	
Metacoceras spp.										1						1	
Parametacoceras cf. *P. bellatulum*					2											2	
Endolobus ortoni			2					1								3	
Endolobus cf. *E. forbesianus*			1		6			2								9	
Temnocheilus annulonodosus					25[2]		3	15	2							45	
Temnocheilus quinqueliratus					1		1									2	
Latitemnocheilus bellicosus							2									2	
Latitemnocheilus medioventralis								1								1	
Latitemnocheilus cf. *L. harneri*					6											6	2
Latitemnocheilus cf. *L. johnsoni*		1	1		3											5	
Latitemnocheilus cf. *L. latus*					2											2	1
Latitemnocheilus? sp. #1									2							2	
Latitemnocheilus? sp. #2			3													3	
Mahoningoceras pottsvillense			1													1	1

Mahoningoceras subquadrangulare			2													2	
Ungeroceras ungeri					13[2]			1[2]								14	1
Domatoceras obsoletum								8								8	
Domatoceras oreskovichi					30			1	3							34	
Domatoceras shepherdi								3	3							6	
Domatoceras williamsi			1[4]				1									2	5
Domatoceras cf. *D. highlandense*											1	1		3		5	2
Domatoceras spp.											1			1+		2+	
Stenodomatoceras gardi											45	1				46	
Stenopoceras smithi														2		2	
Solenochilus bognari							1									1	
Solenochilus cambridgensis												4				4	
Solenochilus greenensis								9	1							10	
Solenochilus johnstoni											3	1				4	
Solenochilus mcfarlandi											12					12	
Solenochilus millhorni					5[2]											5	
Solenochilus peculiare		1	2													3	
Solenochilus cf. *S. springeri*					8[2]											8	
Solenochilus sp.									1							1	
Liroceras liratum	1				15	1	2	40	6		65					129	
Coelogasteroceras dubium											1					1	5
Condraoceras primum												1				1	2
Condraoceras? sp.							1									1	
Ephippioceras ferratum			1		2		3	5				1				12	
Megaglossoceras spp.					1		1				3					5	
Genus indeterminate #1 sp.					1											1	
Genus indeterminate #2 sp.					1						1					2	
Ctenobactrites isogramma			4	1	6		1	1	1							14	
TOTAL	1	62	61	4	951	1	82	195	180	1	942+	76	21	21+	6	2,604	30

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[1] The stratigraphic names in this table are the traditional/historical names used for the Pennsylvanian units in Ohio.
[2] Includes one or more specimens from undifferentiated Putnam Hill-Vanport or Columbiana-Vanport.
[3] An additional 238 Ohio specimens were reported by other authors.
[4] Presumably from the Lower Mercer.

Chapter 1-4

SYSTEMATIC PALEONTOLOGY OF OHIO NAUTILOIDS AND BACTRITOIDS

Genus *Michelinoceras* Foerste, 1932

Type species: *Orthoceras michelini* Barrande, 1874; OD

Michelinoceras Foerste, 1932, p. 47, 51, 72; Miller & Youngquist, 1949, p. 28-29, pl. 7, figs. 8-11; Flower, 1962, p. 10-11; Sweet, 1964, p. K225-K226, fig. 156, 3; Gordon, 1964, p. 105-106.

Diagnosis.—Small, slender, gradually expanded orthoceracones having a circular whorl section, long camerae, and central siphuncle.

Description.—Conch small, long, slim, smooth, very gradually expanded, subcylindrical, orthoceraconic, with circular whorl section, long camerae, and very long body chamber, and central or slightly eccentric orthochoanitic siphuncle; episeptal and hyposeptal cameral deposits normally well developed.

Remarks.—Girty (1908, p. 497, pl. 23, figs. 10, 10a, b; 1909, p. 44-45, pl. 6, figs. 11, 12) first reported slender, long, camerate orthocones from Mississippian and Permian strata of North America. They were referred to the catch-all genus *Orthoceras*, but their distinctive nature was clearly noted. In 1932 Foerste established the genus *Michelinoceras* for slender, long, camerate, straight shells from the Middle Silurian of Bohemia, which Barrande (1874) had first described in his classic monograph. Subsequent authors (for example, Miller and Youngquist, 1949, p. 29-30; Unklesbay, 1962, p. 19-20) have applied this generic name to similar-appearing forms from Pennsylvanian and Permian formations. Sweet (1964, p. K226), apparently following Flower (1962, p. 11), stated the true range of *Michelinoceras* is Ordovician-Devonian. Little is definitely known concerning the features of those relatively rare Upper Paleozoic specimens referred to *Michelinoceras*, so their morphologic and phylogenetic relationships are uncertain. We are following Sweet's (1964, p. K226) suggestion that they be retained in *Michelinoceras sensu lato* and are so placing our few specimens. The Permian genus *Bitaunioceras* Shimizu & Obata (1936, p. 27) differs from *Michelinoceras* noticeably only by its constricted camerae.

Geologic range.—Ordovician-Devonian, Carboniferous-Triassic?

Michelinoceras? *unicamera* (Smith), 1938
Pl. 1-1, figs. 1-7

Orthoceras unicamera Smith, 1935, p. 7, 14-15, pl. 1, figs. 1-3; 1938, p. 4, 7-9, pl. 1, figs. 1-3.

Michelinoceras directum Unklesbay, 1962, p. 19-20, pl. 1, figs. 1-3.

"Orthoceras" unicamera Fischer & Teichert, 1969, p. 11, pl. 1, fig. 1; pl. 2, figs. 2, 3; pl. 3, fig. 3; figs. 3-5.

Diagnosis.—Small, gradually expanded orthoceracones having long camerae; surface ornament reported to be progressively variable, initially a faint cancellate pattern followed by smooth surface and in turn by transverse lirae; protoconch flat, caecum adnate; cameral deposits well developed.

Material.—Our collection contains 12 representatives of this species from Pennsylvanian strata of Ohio. Each is more or less fragmentary and ranges in preservation from isolated camerae to an apparently nearly complete specimen 90 mm long. Several have varying amounts of test, but none retains the apical camera and caecum or mature aperture.

Description.—Conch small, long, expanding very slowly orad at a rate of approximately 2° from adolescent to mature stages; circular in cross section. Test thin, not exceeding 1 mm in thickness on larger individuals; preserved surface ornament consisting of rounded transverse lirae, 3 to 10 per mm, separated by flat or slightly concave channels, locally imbricate in form; smaller, lesser lirae and striae commonly present and additional sharp discontinuous longitudinal lines present. Camerae long and variable in length; septa deep, one-fourth to one-third of cameral length; siphuncle central throughout, septal necks orthochoanitic, connecting rings cylindrical or only slightly expanded between septa; endosiphuncular deposits concentrated ventrally; cameral deposits of planohyposeptal type in first four chambers, mural and episeptal deposits common throughout, mature chambers with episeptal and hyposeptal circuli.

Remarks.—Smith (1938) named and described this uncommon and unusual species in his study of the Desmoinesian Buckhorn Asphalt fauna of Oklahoma. Unklesbay (1962) named and described *Michelinoceras directum* as a new species for conspecific material apparently from the same locality. Fischer and Teichert (1969) and others have studied the affinities and significance of these forms by detailed examination of shell morphology, structure of organic deposits, and the form of initial shell stages.

The most distinctive features of *M.*? *unicamera* are the relatively deep septa and extensive cameral and siphuncular deposits. Although our material is less extensive and not nearly as well preserved as the Buckhorn Asphalt specimens, our observations indicate that they are closer to those from the Buckhorn Asphalt than to any other known species and for the present can best be identified under the same specific name.

Girty (1909, p. 44-45) reported similar representatives from the Chesterian Caney Shale of northeastern Oklahoma. Girty's species, *Orthoceras wapanuckense*, seems to differ principally by its lack of transverse lirae on the shell surface. Girty did not comment on the internal features of the species. Gordon (1964, p. 106) placed Girty's species in *Michelinoceras* and reported additional occurrences in Upper Mississippian rocks of Alaska and Arkansas. He also did not mention the internal features of these species. Forms of Permian age, including specimens earlier reported by Girty

(1908, p. 497), Stainbrook and Madera (1941, p. 382-383), and Miller and Unklesbay (1942a, p. 720), that have since been referred to this genus by Miller and Youngquist (1949, p. 29-30), are too inadequately known for comparisons.

Occurrence.—12 specimens total; Columbiana unit: 1 specimen from loc. Ss-6; Putnam Hill unit: 8 specimens from loc. Ms-3, 1 specimen each from locs. HOc-3, Tsc-1, Vel-19.

Repository.—Hypotypes, OSU 29273 to 29275, 29316 to 29319, and OU F 350, 365.

Genus *Thoracoceras* Fischer de Waldheim, 1844

Type species: *Thoracoceras vestitum*
Fischer de Waldheim, 1844; OD
Melia Fischer de Waldheim?, 1829, p. 325

Thoracoceras Fischer de Waldheim, 1844, p. 755, pl. 17, figs. 1a-d; Hyatt, 1884, p. 275-276; 1900, p. 519, fig. 1064; 1913, p. 600; Miller, Dunbar & Condra, 1933, p. 71-74, fig. 18A-D; Turner, 1954, p. 299; Balashov & Zhuravleva, 1962, p. 84, pl. 10, fig. 13; Sweet, 1964, p. K230, fig. 159, 2a, b; Windle, 1970, p. 21-22.

Diagnosis.—Orthocones characterized by a compressed whorl section and longitudinal ribs bearing short spines or nodes.

Description.—Conch small to medium sized, slightly cyrtoconic (ventrad?) in early growth stages, otherwise apparently orthoconic; whorl section compressed elliptical, H/W ratio approximately 1.25 to 1.30; surface marked by rounded longitudinal grooves separated by intervening cuspate ribs, each bearing a row of small blunt spinose nodes; septa shallow, transverse, saucer-shaped discs; sutures straight, normal to conchal axis; siphuncle small, submarginal, apparently ventrad in position, its structural details unknown.

Remarks.—*Thoracoceras* is similar in its form and appearance to *Kionoceras* Hyatt (Hyatt, 1884, p. 275) and these two genera have been confused. *Thoracoceras* is distinguished from *Kionoceras* by a compressed whorl cross section and by the presence of nodes or spines on the raised longitudinal ornament. *Cyrtothoracoceras* Turner (1954, p. 300-301) is a Mississippian cyrtoconic genus that possesses the ornament of the present genus. Specimens of *Thoracoceras* are rare; it is known only from several widely scattered localities in Europe and North America.

Geologic range.—Mississippian-Pennsylvanian, Permian?

Thoracoceras? sp.
Pl. 1-1, figs. 12, 13

Kionoceras sp. Newell?, 1936, p. 484-485, pl. 70, figs. 2a-c.
Thoracoceras? sp. Miller & Garner?, 1953, p. 176.
Thoracoceras? sp. Windle, 1970, p. 22-25, pl. 1, fig. 1.

Diagnosis.—Doubtful *Thoracoceras* characterized by compressed immature conch bearing 15 or more weakly nodose to apparently smooth longitudinal ribs.

Material.—Three small, incomplete individuals were collected from the Brush Creek unit and one from the Putnam Hill unit. Although three were originally complete apicad, they lacked portions of their phragmocones and all or part of their body chambers. The largest Brush Creek specimen is 16 mm long and partly septate; its adoral half, which is mashed, presumably represents the body chamber (fig. 1-3). The second Brush Creek specimen is only 8 mm long, septate throughout, and undistorted. The third one is only a partial external mold. The Putnam Hill specimen has lost its apical portion and now has a length of 10+ mm, all of which is septate. Unfortunately, two of the Brush Creek specimens have been lost or misplaced.

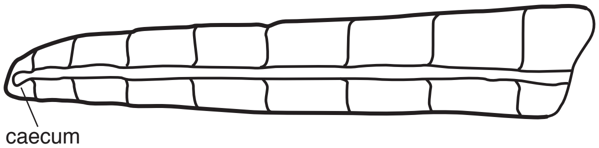


FIGURE 1-3.—*Thoracoceras*? sp. Longitudinal view of a polished specimen showing septa and siphuncle, including caecum; X10; Brush Creek unit, loc. Aa-41; OSU 29240.

Description.—Conch small, slender, slowly expanded orad at an approximate angle of a mere 3°; conch initially cyrtoconic, apparently ventrad, becoming orthoconic between second and third septa; cross section compressed, maximum H/W ratio 1.33. Test relatively thin, ornamented apically by fine, closely spaced, transverse lirae gradually superimposed on approximately 15 obtusely angular longitudinal ribs, transverse growth lirae diminishing adorally and remaining visible as slight thickenings on the progressively larger ribs. Septa nearly transverse to conchal axis with little or no convexity, distance between adjacent septa gradually increasing toward aperture; conchal width 0.10 to 0.35 greater than corresponding cameral length; caecum bulbous, siphuncular diameter relatively constant and approximately 0.12 of conchal height in adoral chambers of preserved portion; connecting rings cylindrical or very slightly expanded with center midway dorsoventrally in initial camera, adaperturally moving to less than 0.40 of conch height above venter (?); septal necks short, initially achoanitic (?), becoming loxochoanitic to weakly orthochoanitic adorally; body chamber and aperture unknown.

Remarks.—Late Paleozoic orthoconic or slightly cyrtoconic nautiloids that have longitudinal ribs commonly have been referred to *Kionoceras* or *Thoracoceras*. They are with minor exceptions rare, but do occur in a few widely scattered localities. Examples are known from the Missourian Series of Kansas (Newell, 1936; Miller and Garner, 1953), the Desmoinesian Buckhorn Asphalt (Fischer and Teichert, 1969) and the Boggy Formation (observed by authors) of Oklahoma, the Cherokee Formation (also observed by authors) of Iowa, the Viséan of Alaska (Gordon, 1957), and the Lower Permian of Texas (Miller and Youngquist, 1949) in North America. Additional specimens have been reported from Belgium, the British Isles, and the former Soviet Union. Certain of these forms do fit better the concept of the genus *Kionoceras*, although it seems unlikely that they are closely related to older Paleozoic representatives referred to that genus. It is indeed possible that these scattered Late Paleozoic individuals represent several species and more than one genus. Resolution of these taxonomic questions will depend on further collecting and detailed critical study of all available Paleozoic specimens.

Occurrence.—4 specimens total; Brush Creek unit: 3 specimens from loc. Aa-41; Putnam Hill unit: 1 specimen from loc. Spk-1.

Repository.—OSU 29240, 29249.

Genus *Brachycycloceras* Miller, Dunbar & Condra, 1933

Type species: *Brachycycloceras normale* Miller, Dunbar & Condra, 1933; OD

Brachycycloceras Miller, Dunbar & Condra, 1933, p. 105-107; Furnish, Glenister & Hansman, 1962, p. 1345-1347 (in part); Balashov & Zhuravleva, 1962, p. 84-85; Furnish & Glenister, 1964, p. K232-K234 (in part), fig. 162, fig. 163, 2a-d; Windle, 1970, p. 25-28 (in part); 1973, p. 90-96.

Diagnosis.—Weakly to moderately expanded, annulate orthoceracones, with a blunt apex and with or without abruptly flared adoral margins; test thin, exterior marked by transverse annuli and growth lirae dorsally and ventrally and deflected laterally in a shallow distinct re-entrant (ocular sinus?) developed nearer to the ventrolateral boundary; septa also thin; no internal deposits.

Description.—Conch small to medium sized, annulate, orthoconic, variably expanded from 10° to 25°; apex blunt and marked by fine transverse lirae, adoral margin abruptly expanded on some specimens; test wrinkled into corrugated annulations except on adoral flared margins and marked by variable growth lirae parallel to annulations; both features transverse dorsally and ventrally, or defining broad, shallow dorsal and ventral salients and also forming shallow but distinct lateral or ventrolateral re-entrants; septa moderately convex; siphuncle ventrad in position, located nearer to venter than to center of conch.

Remarks.—Windle's 1973 study (p. 90-96) of the genus *Brachycycloceras* indicates a scarcity of sufficiently well-preserved specimens from definite horizons and localities for adequate determination of species and their distributions. The thin tests of these specimens must have been easily broken, so that well-preserved conchal portions are rather uncommon. *Brachycycloceras longulum* Miller & Owen is the only species for which details of the apex and most of the conchal length are well known, but even for this species the adoral margin and precise surface ornament are uncertain. It is apparent that better, larger, and stratigraphically documented collections are needed for complete definition of even that species.

On the basis of what appeared to be valid evidence, Furnish, Glenister, and Hansman (1962, p. 1342-1345) interpreted the annulate orthoconic shells of *Brachycycloceras* as the immature deciduous portions of conchs that developed into breviconic cyrtocones at maturity. The supposed molting of the annulate portion was interpreted to have occurred at a specialized thickened septum. Analogous structures and conch forms have been known for many years in Ordovician and Silurian Ascocerida (Lindström, 1890), and separation of the immature shell is documented. In the ascoceroids the septum of truncation not only served as the plane of separation of the two conchal portions, but also after decollation functioned as an external shell in protecting the posterior of the animal's body (Moore, Lalicker and Fischer, 1952, p. 351, fig. 9-12). Furnish and others (1962, p. 1346, fig. 1A) thought that they had discovered a septum of truncation in a cyrtoconic form which lacked its apical portion. They observed additional evidence that included similar cyrtoconic forms associated with annulate orthocones; two of the latter retained abruptly expanded anterior portions suggestive of the cyrtoconic shell (Furnish and others, 1962, pl. 179, figs. 2, 3). Earlier, Hansman (1955, pl. 2, figs. 1-6) had illustrated several specimens of *B. kentuckiense* Miller, Dunbar & Condra showing smooth, abruptly flared, but incomplete adoral portions of the conch.

Windle (1973, p. 41-50, 89-90, 201-206) observed rather convincing evidence that *Brachycycloceras* specimens are not decollated immature stages of Late Paleozoic cyrtoconic brevicones. His pertinent observations include:

Brachycycloceras:	Cyrtoconic brevicones:
1. Rapidly expanded adoral portion orthoconic, not cyrtoconic,	1. Immature stage cyrtoconic more so than adult portion, never orthoconic,
2. No fully septate conchs known,	2. None marked by finely lirate to smooth shell surface,
3. No thickened septum observed between annulate shell and abruptly expanded portion.	3. No septum of truncation recognized.

The abrupt flare of annulate shells observed by Hansman (1955) and by Furnish and others (1962) is interpreted as a mature modification of the anterior conchal margin.

The test and septa of *Brachycycloceras* are unusually thin. Despite the fragile nature of the shell and septa and the elongate conch form, no internal deposits have been observed in representatives of the genus. Shell strength is increased to some extent by the slightly thickened annulations. This shell construction suggests that these annulate forms were buoyant and probably active swimmers. If they inhabited benthic areas, their attitude may have been inclined or vertical. The latter idea is supported by the outline of the peristome and conch cross section through ontogeny. The adoral margins are slightly projecting dorsally and ventrally. Laterally, but centered nearer the ventrolateral shoulder, there is a shallow but distinct re-entrant. The transverse section is distinctly subquadrate to subtrapezoidal with a narrower venter. This combination in the peristomal outline is strongly reminiscent of cyrtoconic forms, which have strong indication of a vertical or inclined orientation during life.

The ancestry of *Brachycycloceras* is uncertain. *Reticycloceras* Gordon is not seriously considered a possible precursor, as the two genera occur together in Chesterian-age strata and neither is known in older beds. These two genera can be distinguished on the form of the apical extremity and the occurrence of primary deposits in *Reticycloceras* and lack of them in *Brachycycloceras*. Both forms were possibly derived from older annulate forms similar to annulate shells described by Miller and Garner (1953, p. 178, pl. 3, fig. 7; p. 180-183, pl. 3, fig. 6) from Mississippian formations of Michigan such as *Dinocycloceras ehlersi* (Miller & Garner) or possibly *Spyroceras*-like forms. *Brachycycloceras* is similar to *Dinocycloceras* Gordon (1964, p. 129-131, fig. 12A) and the two are possibly synonymous. *Dinocycloceras* is characterized by deep septa, long camerae, and an eccentric ventral siphuncle. A species questionably assigned by Furnish and others (1962, pl. 179, fig. 1; fig. 3A) to *Brachycycloceras* and later named *B.*? *spectrum* by Hansman (1965, p. 729-730) does not seem to fit the present concept of the genus. Representatives of *Brachycycloceras* are known from Asia, Australia, Europe, and North America.

Geologic range.—Upper Mississippian (Chesterian)-Upper Pennsylvanian, Lower Permian?

Brachycycloceras longulum Miller & Owen, 1934

Pl. 1-2, figs. 1, 4, 5

Brachycycloceras longulum Miller & Owen, 1934, p. 208-209, pl. 8, figs. 1-4; Unklesbay, 1962, p. 22, pl. 1, fig. 7; Windle, 1973, p. 96-103, 396-398, table 10 (in part), pl. 1, figs. 3-8, pl. 2, figs. 6-8.

Brachycycloceras n. sp. Sturgeon, 1937, p. 357.

Brachycycloceras ohioense Sturgeon, 1946, p. 12, 14-16, pl. 3, fig. 13; fig. 2.

Brachycycloceras bransoni Furnish, Glenister & Hansman, 1962, p. 1351-1354, fig. 3B (in part).

Diagnosis.—*Brachycycloceras* characterized by low rate of expansion except for rapidly expanded apical portion (fig. 1-4), long body chamber, and closely spaced annulations, which are replaced on mature (?) body chambers by weak lamellae.

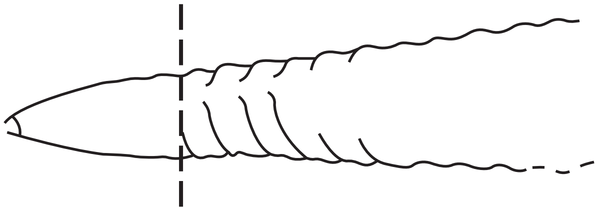


FIGURE 1-4.—*Brachycycloceras longulum* Miller & Owen. Long view of a partially polished section of a hypotype (formerly holotype of *B. ohioense* Sturgeon) showing rapid expansion of apicad part of conch and some details of the septa and siphuncle; X5 (approx.); Columbiana unit, loc. Mg-2; OSU 18707 (also see pl. 1-2, figs. 4, 5). After Sturgeon (1946).

Material.—One small and incomplete conch, originally the holotype of *Brachycycloceras ohioense*, came from the Columbiana unit, and a dozen specimens from the Mid-continent region were observed by Windle. These latter specimens have maximum approximate lengths up to 75 mm and diameters up to 15 mm. The specimen from the Columbiana unit has a preserved length of 14 mm and a maximum diameter of only 3.5 mm.

Description.—Conch small to medium sized, orthoconic, normally expanded at rates of 9° to 14° (only 8° for Columbiana specimen) in immature portion, slightly more toward margin of larger specimens and much greater in blunt, bullet-shaped apical portion; conch cross section initially circular, becoming distinctly subtrapezoidal with slightly convergent ventrad flanks at a diameter of 5 to 6 mm, slightly compressed between diameters of 4 to 8 mm and weakly depressed at larger diameters; intermediate and mature dorsum and venter broadly rounded, flanks distinctly less convex, shoulders rounded and indistinct. Test thin, ranging from 0.1 to 0.4 mm in thickness, thickest in annulations; blunt apical extremity ornamented by threadlike transverse lines, annulations first appear 2 mm from apex at a conch diameter of 1.8 mm; annulations progressively more widely separated orad by much wider somewhat flattened troughs; both annulations and troughs marked by fine, equidimensional lirae, increasing in number with growth; 20 lirae between crests of two adjacent annulations at junction between rapidly and evenly expanded portions, lines on annulations finer than those on troughs; initial annulations directly transverse; immature and mature ones inclined to long conchal axis, farthest apicad on venter and forming ventrally a weak broad re-entrant, dorsally a similar weak salient, and laterally a shallow re-entrant (ocular sinus?); annulations obsolescent at conch diameters in excess of 10 to 20 mm and replaced by closely spaced (4-5 in 2 mm), asymmetrical lamellae following same growth pattern as annulations. Suture pattern of immature specimens forming a broad low dorsal salient and a broad shallow ventral lobe; body chamber exceptionally long, attaining a length of 1½ times the length of the phragmocone; septa thin, spaced 0.7 to 0.9 mm apart at conchal diameters of 2.25 to 3 mm, or a ratio of almost 3:1, and oblique with dorsal edge farther orad; septal convexity between 0.32 and 0.45 mm at conchal diameters of 2.2 and 2.6 mm, or an approximate ratio of 6:1; siphuncle ventrad in position, ranging between one- eighth and one-third of distance above venter, small at its passage through septa; septal necks short, slightly recurved, extended one-fifth of cameral length; connecting rings not preserved; no cameral or siphuncular deposits observed.

Remarks.—*Brachycycloceras longulum* differs from other known species by its closely spaced annulations, replacement of the annulations by weak lamellae on the mature part of the conch, low rate of conchal expansion, blunt, bullet-shaped apical portion, and very long body chamber. It is the only species known that has the apex of the conch preserved.

Furnish, Glenister, and Hansman (1962, p. 1351) suggested that *B. longulum* and *Poterioceras bransoni* Miller & Owen, a large cyrtoconic form, are conspecific, and they interpreted *B. longulum* as the deciduous part of *P. bransoni* (Furnish and others, 1962, p. 1352, fig. 3B). Windle's later study (1973, p. 90-96) of *Brachycycloceras*, based on the data listed under our description of the genus, indicates that their interpretation was a misconception. They also placed *B. ohioense* in synonymy with *B. bransoni* (Miller & Owen), but we are following Windle's (1973, p. 96) interpretation by placing it under *B. longulum*, because they appear to be conspecific and *B. longulum* has priority.

Occurrence.—1 specimen; Columbiana unit: loc. Mg-2.

Repository.—Hypotype, OSU 18707 (formerly holotype of *B. ohioense*).

Brachycycloceras spp.
Pl. 1-2, figs. 2, 3, 6, 8-10; pl. 1-43, fig. 3

Brachycycloceras sp. Windle, 1970, p. 29-30, pl. 1, fig. 2.

Diagnosis.—Fragmentary specimens up to 30 mm in length showing some details of conchal size and form, annulations and troughs, and fine annular surface ornamentation.

Material.—Between three and four dozen incomplete specimens have been collected from widely scattered localities and stratigraphic units ranging from the Lowellville (Poverty Run) unit in the Pottsville Group to the Ames unit in the Conemaugh Group. The specimens consist of various fragments ranging from slightly distorted pieces of conch with lengths up to 30 mm to flattened partial molds with or without test remnants. Most of our observations were confined to details of annulations and finer surface ornament, which revealed considerable variation among the specimens and even some variation on the same individual.

Remarks.—Distance between annulations ranges from less than 1 mm to 3.3 mm and averages about 1.5 mm for the smaller specimens and almost 3.2 mm for the larger ones. Average distance between annulations on 15 specimens from the Upper Mercer, Putnam Hill, Vanport, Columbiana, and Washingtonville units is 1.4 mm, which may be representative for spacing on earlier growth stages. Three fragments, one each from the Boggs, lower Brush Creek, and Ames units, have spacing of annulations from 3 to 3.3

mm. These specimens are larger than those with closer spacing; the spacing differences appear to be proportionate to specimen size.

Lines and striae vary in number and strength among the several specimens and on the same individual; those on the troughs are normally stronger and more numerous than those on the ridge crests (pl. 1-2, figs. 3, 9). Lines on the troughs range from 6 to as many as 16 and average about 10 or 11; lines on the ridges range from 7 to 10 and average 9. These fine markings are not well preserved on some specimens and possibly may not be present on some ridge crests.

It is impossible to make positive specific identifications for these fragmentary specimens or to determine definitely whether they represent more than one species. It is possible that those from the Columbiana unit, and other similar specimens, represent *Brachycycloceras longulum*. Windle (1973, p. 119) has tentatively identified the specimen from the Ames unit (OSU 28815; pl. 1-2, fig. 8) as *B. normale*. Because of its incompleteness and uncertainty, we prefer not to surmise its specific identify.

Occurrence.—45 specimens total (some broken into two or more pieces); Ames unit: 1 specimen from loc. Aal-41; Lowellville (Poverty Run) unit: 1 specimen from loc. Tfr-1; Brush Creek unit: 4 specimens from loc. Aa-41, 2 specimens from loc. Cma-5, 1 specimen from loc. Cma-3; Columbiana unit: 4 specimens from loc. Cs-3, 3 specimens from loc. Mg-10, 1 specimen each from locs. Cp-3 and Ts-4; Portersville unit: 2 specimens from loc. Pb-1; Putnam Hill unit: 6 specimens from loc. Ms-3, 4 specimens each from locs. Mg-3 and MUho-9, 1 specimen each from locs. Mc-2, MUc-2, and Ty-3; Upper Mercer unit: 1 specimen from loc. Twy-2; Vanport unit: 2 specimens from loc. Vel-20, 1 specimen each from locs. Cer-3, Csc-1, JEsa-2, and MUho-3; Washingtonville unit: 1 specimen from loc. MUmu-1.

Repository.—OSU 18743, 18744, 28806 to 28809, 28811 to 28817, 28820, 30612; OU F 236 to 240, 377, 379, 381 to 385, 392.

Brachycycloceras? cf. *B.*? *spectrum* Hansman, 1965
Pl. 1-2, fig. 7

Brachycycloceras? n. sp. Furnish, Glenister & Hansman, 1962, p. 1347, 1352, pl. 179, fig. 1; fig. 3A.
Brachycycloceras? *spectrum* Hansman, 1965, p. 729-730.

Diagnosis.—Annulated orthocones possessing three types of surface features.

Material.—A single incomplete specimen, collected in 1921 by C. F. Moses and W. E. Stout from the Vanport unit, is the only specimen available. It is a weathered, flattened mold that is incomplete at each end and along the sides. It has a preserved length of 17.8 mm and a width of 7 mm. This external mold shows three types of surface features. Below the surface of the mold are sinuous depressed lines that possibly are borings, trails of worms, or traces of worm tubes removed by solution.

Description.—Surface of apical end marked by rounded ridges about 1.5 mm apart and separated by broadly rounded, shallow furrows; these annulations decrease in size orad and almost disappear completely in a distance equal to that between three ridges; adjacent area orad about 4 mm wide, almost smooth but having one or two faint ridges and troughs; remainder of surface having small annular lirae and striae (16 in a distance of 7 mm, or averaging 0.44 mm apart), coarser and farther apart toward apicad end and finer and more closely spaced toward orad end. No other features preserved except extraneous traces of borings, trails, or tubes.

Remarks.—In a general way our specimen resembles the one figured by Furnish, Glenister, and Hansman (1962, pl. 179, fig. 1). There are, however, several apparent differences between these two specimens. Our specimen is a much smaller individual that has coarser annulations toward the apicad end. In addition, our specimen has a nearly smooth area between the annulated area and the striated area; their specimen does not. Finally, ours has diminution in size of the striae and lirae orad, and theirs has uniform size of striae and lirae over the entire lined area. Before the generic and specific identity of the specimen under consideration can be determined positively, more complete and better specimens must be collected and observed.

Occurrence.—1 specimen; Vanport unit: loc. Csc-1.

Repository.—OSU 28810 (hypotype?).

Genus *Pseudorthoceras* Girty, 1911

Type species: *Orthoceras knoxensis* McChesney, l860; OD

Pseudorthoceras Girty, 1911, p. 143; 1915, p. 227; Miller, Dunbar & Condra, 1933, p. 77-81; Flower & Caster, 1935, p. 30-31; Flower, 1939, p. 139; Shimer & Shrock, 1944, p. 553, pl. 227, fig. 1; Miller & Youngquist, 1949, p. 18; Sweet, 1964, p. K244, fig. 173, 7; Gordon, 1964, p. l09.

Diagnosis.—Long, slender orthocones, slightly cyrtoconic in earliest growth stage; siphuncle central or subcentral in position, variable in structure, changing from suborthochoanitic and finally to cyrtochoanitic during ontogeny; endosiphuncular deposits continuous adorally; episeptal and mural cameral deposits well developed.

Description.—See following description of type species, *Pseudorthoceras knoxense* (McChesney).

Remarks.—The type species is the most common and most widespread, both geographically and stratigraphically, Pennsylvanian cephalopod species in Ohio and in North America. We have approximately 1,300 incomplete specimens representing almost every Pennsylvanian marine unit of Ohio. The similar and closely related genus *Mooreoceras* Miller, Dunbar & Condra commonly occurs in lesser numbers with *P. knoxense* and is always represented by incomplete adolescent or mature phragmocones with or without part of the body chamber and lacking the apical part of the conch. A comparison of the principal similarities and differences between these two genera reveals that *Pseudorthoceras* has a circular whorl section, a nearly central siphuncle, and is replete with organic deposits, particularly in the posterior camerae and siphuncle. *Mooreoceras* has a slightly depressed circular whorl section, an eccentric siphuncle, and possibly only ventral cameral and unfused siphuncular deposits. Flower (1957, p. 846) suggested that *Pseudorthoceras* and *Mooreoceras* may represent different conchal portions of the same species, for the following reasons: numerous apical extremities of *P. knoxense* are available and none is known from *M. normale* Miller, Dunbar & Condra; the preserved remains of *P. knoxense* are generally smaller in diameter than those of *M. normale*; the modification of cameral and siphuncular deposits in *Mooreoceras* can be explained by solution or resorption; and the deposits become thin and possibly disappear orad in *Pseudorthoceras*. To us, all observations that they are conspecific are inconclusive, and we are tentatively recognizing both genera as valid.

Geologic range.—Upper Devonian-Lower Permian.

Pseudorthoceras knoxense (McChesney), 1860
Pl. 1-3, figs. 1-21

Orthoceras knoxensis McChesney, 1860, p. 69.

Orthoceras rushensis McChesney?, 1860, p. 68; Mark?, 1912, p. 52, 265, 270, 275, 277, 279, 282, 285, 287, 299.

Orthoceras cribrosum Geinitz?, 1866, p. 4, pl. 1, fig. 5; Meek, 1872, p. 234, pl. 11, figs. 18a, b.

Pseudorthoceras knoxense Girty, 1911, p. 143; 1915, p. 227-234, pl. 27, figs. 1-6; Morningstar, 1922, numerous citations, p. 144, 268-269; Miller, Dunbar & Condra, 1933, p. 81-85, pl. 1, figs. 4-9; Miller & Owen, 1934, p. 196-198, pl. 8, fig. 6; Sturgeon, 1937, p. 358; 1946, p. 12-14, pl. 3, figs. 5-9; Flower, 1939, p. 140-142, pl. 1, fig. 6; pl. 2, fig. 11; pl. 8, figs. 5, 11, 12; fig. 17A-F; Miller & Unklesbay, 1942b, p. 128-131, pl. 1, figs. 1-5; Unklesbay, 1954, p. 88-90; 1962, p. 22-24, pl. 1, figs. 10, 11; Lintz, 1958, p. 100; Hoare, 1961, p. 129, pl. 16, fig. 4, pl. 17, fig. 1; Gordon, 1964, p. 109-111, pl. 5, figs. 19, 20; Sweet, 1964, p. K244, fig. 173, 7; Davis & Campbell, 1968, p. 279-284, figs. 2, 3; Fischer & Teichert, 1969, p. 8-9, 16-17, pl. 2, fig. 4; pl. 3, figs. 1, 4b; pl. 4, figs. 1, 4; figs. 1, 2; Windle, 1970, p. 32-36, pl. 1, figs. 3-5.

Pseudorthoceras seminolense Girty?, 1911, p. 143-144; 1915, p. 234, pl. 27, figs. 7-8a.

Diagnosis.—*Pseudorthoceras* characterized by initial cyrtoconic shell, pyriform to subglobular siphuncular segments, and camerae replete with episeptal and mural deposits; species variable.

Material.—This species is the most abundant nautiloid in our collection. The exact number of individuals is difficult to determine because most specimens are broken along septal surfaces, but approximate count is more than 1,300. Available specimens are relatively small (none exceeds 150 mm in length); many are complete apicad, all are incomplete adorally, and many are mashed toward that extremity.

Description.—Conch straight except for slightly curved apical portion; long, slender, normally gradually and regularly expanded orad, averaging approximately 7°; a few specimens expanded more rapidly near apicad end (pl. 1-3, figs. 4-6, 9); circular or weakly subelliptical in cross section; test thin and smooth externally except for faint sinuous growth lirae; aperture not observed. Internal mold smooth except for conchal furrow and sutures; sutures simple and essentially circular, slight lobations developed dorsally and ventrally in larger specimens; septal planes saucer-shaped discs, moderately convex apicad, convexity approximately one-fifth of conchal diameter; septal spacing somewhat irregular, two to five occupying a distance equal to conch diameter; primary episeptal and mural cameral deposits concentrated ventrally; apicad chambers replete with deposits, reduced to thick surface linings orad; mural deposits reduced more rapidly than episeptal deposits; deposits not in contact with connecting rings of siphuncle except in apicad chambers; secondary parietal calcite fillings apparent in some adoral chambers; siphuncle central in apicad chambers, subcentral to slightly ventrad orad; segments subcylindrical apicad becoming cyrtochoanitic orad; endosiphuncular deposits concentrated ventrally, forming a continuous lining along that surface; septal foramen small, approximately one-half of maximum siphuncular diameter; adnation area and brim well defined; connecting rings thin walled, expanded, subcylindrical apicad, inflated pyriform orad; postembryonic caecum subspherical, long axis oblique to succeeding camerae; cicatrix generally absent.

Remarks.—In 1860 McChesney named and briefly described, without illustrations, specimens of *Orthoceras knoxensis* from the Pennsylvanian McLeansboro Group of Knox County, Illinois. His type specimens were subsequently destroyed by fire, hence exact status of the species is uncertain. The present understanding of *Orthoceras knoxensis* is based on the rather detailed description by Girty, who in 1911 applied McChesney's specific name to specimens from the Wewoka Formation of Oklahoma and established the new genus *Pseudorthoceras* for them. Subsequent observers have accepted Girty's resurrection of McChesney's species, although it is not certain that his opinion is correct.

A few apicad specimens have very rapid expansion of the conch and have developed into more robust individuals than most others (pl. 1-3, figs. 4-6, 9). It is uncertain whether these specimens are individual variants, sexual dimorphs, mutants, or another species or subspecies. Their small numbers suggest that they are not dimorphs, but whether they are one of the other suggested possibilities is a matter of conjecture at present. Possibly they should be referred to *Pseudorthoceras seminolense* Girty.

Much of the detailed knowledge of this species is the product of Flower's (1939) extensive studies regarding its conch morphology and the structure and distribution of primary cameral and siphuncular deposits. In addition, he discussed the phylogenetic history of the genus. In 1957, Flower (p. 846) suggested that this species and *Mooreoceras normale* might be both congeneric and conspecific. Our observations have added little additional information and have mostly substantiated those of Flower. Davis and Campbell (1968) made a detailed study of moderately well preserved specimens from the Cherokee Formation of Iowa. The largest of their specimens has a length of 70 cm and a maximum girth of the body chamber of 25 cm. Also preserved are the caecum, moderately thickened body-chamber wall, and portions of the peristome. Fischer and Teichert (1969) studied well-preserved specimens of *P. knoxense* and some related forms from the Desmoinesian Buckhorn Asphalt of Oklahoma. They reviewed the history of the study of cameral deposits and described the general morphology of those well-preserved representatives. They also presented two opposed hypotheses on the physiologic mechanisms involved in formation of cameral deposits.

Occurrence.—1,321 specimens total; Ames unit: 2 specimens from loc. No-1; Brush Creek unit: 135 specimens from loc. Cma-3, 95 specimens from loc. Aa-41, 8 specimens from loc. Cfr-1, 6 specimens from loc. Ale-18, 3 specimens each from locs. Ale-35 and MEco-1, 2 specimens from loc. Ad-4, 1 specimen from loc. Aw-48; Cambridge unit: 57 specimens from loc. Ls-1, 8 specimens from loc. Gwe-2; Columbiana unit: 19 specimens from loc. Cp-3, 10 specimens from loc. Mg-2, 5 specimens from loc. Ts-4, 1 specimen from loc. Cs-3; Gaysport unit: 5 specimens from loc. No-5; Lowellville (Poverty Run): 30 specimens from loc. MUho-5, 28 specimens from loc. Tfr-1, 1 specimen from loc. Mp-1; Lower Mercer unit: 27 specimens from loc. Hfg-5, 3 specimens from loc. Vel-26, 2 specimens from loc. MUuc-1, 1 specimen each from locs. Pj-2, Sb-2, and Tl-7; Portersville unit: 7 specimens from loc. Pb-1, 4 specimens each from locs. Aa-12 and Gwe-2; Putnam Hill unit: 131 specimens from loc. Ty-3, 120 specimens from loc. Hw-16, 96 specimens from loc. Ms-3, 84 specimens from loc. Vel-15, 59 specimens from loc. Tg-1, 42 specimens from loc. Vel-12, 28 specimens each from locs. Me-3 and Mg-3, 26 specimens from loc. Mg-4, 25 specimens from loc. Mc-2, 21 specimens from loc. Vel-11, 7 specimens from loc. Mc-1, 4 specimens each from locs. MUsp-1 and Pmc-4, 1 specimen from loc. HOc-3; Putnam Hill-Vanport undifferentiated: 22 specimens from loc. Vel-19, 16 specimens from loc. Ms-2, 15 specimens from loc. Td-4, 14 specimens from loc. Tsc-1, 2 specimens from loc. MUho-3; Upper Mercer unit: 1 specimen from loc. Twy-2; Vanport unit: 20 specimens from loc. Jmi-2, 10 specimens from loc. Ts-1, 3 specimens from loc. Vs-3; Washingtonville unit: 50 specimens from loc. Car-2, 9 specimens from loc. CSv-3, 7 specimens from loc. Mg-11, 2 specimens each from locs. Cc-2, Cc-4, and MUmu-1, 1 specimen from loc. Cf-1.

Repository.—Hypotypes, OSU 4711, 4714, 18701, 19676 to 19679, 24632, 24655, 24713, 26759, 29250 to 29257, 29267, 29268, 29276 to 29283, 29286 to 29300, 29347, 29348, 29350 to 29353, 29355 to 29360, 29362 to 29399, 29401 to 29421, 29424, 29425, 30607, 30608, 30610.

Genus *Mooreoceras* Miller, Dunbar & Condra, 1933

Type species: *Mooreoceras normale* Miller,
Dunbar & Condra, 1933; OD

Mooreoceras Miller, Dunbar & Condra, 1933, p. 85-87; Flower, 1939, p. 146-147; Shimer & Shrock, 1944, p. 553, pl. 226, figs. 14, 15; Miller & Youngquist, 1949, p. 23; Sweet, 1964, p. K244, fig. 173, 4a-c; Gordon, 1964, p. 111-113; Windle, 1970, p. 36-40.

Diagnosis.—Small to large, straight pseudorthoceratids characterized by a smooth surface, low rate of normal conchal expansion, circular to slightly depressed cross section, central to subcentral cyrtochoanitic siphuncle, siphuncular deposits similar to but less complete than those of *Pseudorthoceras*, and ventrally restricted cameral deposits.

Description.—See following remarks concerning the type species of *Mooreoceras* and *Pseudorthoceras*; a close relationship between them is suggested, as discussed under the generic description of *Pseudorthoceras*. It is indeed possible that these two genera may not only be congeneric, but their type species may be conspecific.

Remarks.—There is some controversy concerning the occurrence of primary organic deposits in the siphuncles and camerae of members of this genus. The type species, *M. normale*, and allied species, described by Miller, Dunbar, and Condra (1933) and in subsequent reports (Miller and Owen, 1934; Miller and Unklesbay, 1942b, 1947; Miller, 1945; Miller and others, 1947; Sturgeon and Miller, 1948; Miller and Youngquist, 1949; Miller and Garner, 1953) indicate no evidence of primary organic deposits within the camerae and siphuncle. Flower (1939, p. 147-153) and Gordon (1964, p. 113-115) have referred to this genus several species which contain deposits similar to those in typical *Pseudorthoceras* from the Upper Devonian and the Upper Mississippian, respectively. Specimens of Flower and Gordon are nearly complete, well-preserved conchs that retain most of the apical camerae. Those forms described by Miller, Dunbar, and Condra (1933) were largely fragments of "mature" specimens with no complete, well-preserved representatives. Miller and Youngquist (1949) reported that among all of the Late Paleozoic specimens examined by them, they found no evidence of primary organic deposits. In fact, they state that the lack of organic deposits is a critical characteristic of the genus. The deposits described by Flower and by Gordon occur most abundantly in the apical chambers and decrease rapidly orad. This observation is indeed in agreement with the deposits observed in *Pseudorthoceras*. Our specimens of *Mooreoceras* from the Pennsylvanian System of Ohio are very similar to those described by Miller and his coworkers in that most specimens comprise "mature" portions of phragmocones that lack the apical or "immature" camerae and primary organic deposits.

Geologic range.—Upper Devonian-Lower Permian.

Mooreoceras normale Miller, Dunbar & Condra, 1933
Pl. 1-4, figs. 1-7, 9, 11, 14-16

Mooreoceras normale Miller, Dunbar & Condra, 1933, p. 87-89, pl. 2, figs. 5-7; Miller & Owen, 1934, p. 203-204, pl. 11, figs. 1-6; Sturgeon, 1937, p. 358; 1946, p. 12, 14, pl. 3, figs. 10-12; Hoare, 1961, p. 128, pl. 16, fig. 5; Unklesbay, 1962, p. 25-27, pl. 1, figs. 14, 15; Sweet, 1964, p. K244, fig. 173, 4a-c; Gordon, 1964, p. 113, pl. 8, figs. 14-16, 23.

Mooreoceras sp. cf. *M. normale* Windle, 1970, p. 40-42, pl. 1, figs. 12, 13, 15.

Mooreoceras normale uniconstrictum Miller & Owen?, 1934, p. 204-205, pl. 11, figs. 7, 8; Windle, 1970, p. 42-43, pl. 1, fig. 16.

Mooreoceras normale n. var. Windle?, 1970, p. 43-46, pl. 1, figs. 6-8.

Mooreoceras? sp. Windle?, 1970, p. 46-48, pl. 1, figs. 9-11.

Diagnosis.—See generic diagnosis.

Material.—This species is common and widespread but normally not abundant. We have approximately 150 fragmentary specimens representing individuals from stratigraphic sources extending from the Putnam Hill unit at the base of the Allegheny Group upward to the Gaysport unit of the Conemaugh Group. A typical specimen is a conchal section incomplete at both ends and consisting of part of a body chamber, part of a phragmocone, or parts of both body chamber and phragmocone. There is considerable size diversity among individuals assigned to this species. Our longest specimen (OSU 29343), of questionable identity, has a preserved length of 35 cm; exemplary specimens in our collection have an average conch diameter of 25 mm. Several specimens exceed 50 mm in diameter, and even approach 70 mm. A larger specimen that has an estimated diameter of 100 mm is known and may belong here, but was not available for observation.

Description.—Conch medium sized to large, orthoceraconic, gradually and regularly expanded at an approximate expansion angle of 8°; conch cross section subcircular in outline, slightly depressed, dorsum more rounded than venter; apertural margin apparently having a broad, low dorsal salient and an equally broad, shallow ventral re-entrant. Test moderately thin, ranging from 0.5 mm on an average-sized specimen to more than 3 mm on largest specimens; surface normally smooth appearing and only rarely showing visible ornament; ornamented by numerous fine, inconspicuous, slightly sinuous growth lines and by finer, straight, longitudinal lirae. Internal mold smooth, except for sutures and a faint longitudinal ridge on ventral surface, and a partial constriction formed by inward thickening of test around body chamber of presumably mature individuals. Sutures essentially transverse to long axis and slightly sinuous; one specimen (OSU 29311, pl. 1-4, fig. 3) shows a very shallow ventral lobe, equally shallow and wide lateral saddles, extremely faint, shallow dorsolateral lobes, and an equally faint dorsal saddle; septa smooth, saucer-shaped discs, moderately convex apicad, some unequally convex, maximum convexity just below center; ratio of septal spacing to conchal diameter ranging from 4:1 to 6:1; siphuncle eccentric, ranging from slightly to strongly ventrad in position, cyrtochoanitic, narrow at passage through a septum and much expanded within the camerae; septal necks short, distinctly recurved; expanded connecting rings pyriform to subglobular in shape (pl. 1-4, figs. 1, 5).

Remarks.—The original description of *M. normale* was quite complete and thorough, but subsequent investigators have assigned to the species specimens variable in size, septal spacing, and position of the siphuncle. Other species of *Mooreoceras* have been named in North America, and differentiation among them has not always been clearly defined. In addition, there is the unresolved question of the relationship between *Mooreoceras* and *Pseudorthoceras*. Because there is need of further study and clarification of these two genera and of their several species, we are interpreting *M. normale* with rather broad limits and with recognition that we may have included more than one species and/or subspecies. We believe that *Mooreoceras normale uniconstrictum* Miller & Owen, with its constriction across the interior of the body chamber, is probably the mature stage of a *Mooreoceras*, but, because of wide variation in size of specimens possessing a constriction, we are uncertain whether this feature is peculiar to one species or common to several species. If a constriction is a mature feature for several species, those species will have to be recognized by variations in the constrictions and by other conchal features. We are uncertain concerning the validity of *Mooreoceras bakeri* Miller, Dunbar & Condra, *M. condrai* Newell, *M. conicum* Miller, Lane & Unklesbay, *M. augusticameratum* Miller, Dunbar & Condra, and *M. ovale* Young, although it is likely that one or more, possibly all, are valid species or subspecies.

Several of our specimens (pl. 1-4, figs. 14, 16) assigned to this species are much larger than the average size of our other known individuals. The correct taxonomic position of these large specimens, similar in size to those included by Miller and Owen (1934, p. 203, pl. 11, fig. 1) and by Unklesbay (1962, pl. 1, fig. 15), is of concern to us. *Mooreoceras bakeri* cited above and *M. giganteum* Clifton (Clifton, 1942), a Permian species, are characterized by large size, but it is doubtful that our largest specimens are conspecific with either of them. *Mooreoceras tuba* (Girty), distinguished by its flaring apertural margin and relatively small size, appears to lack a constriction and to be a valid species.

Occurrence.—153 specimens total, several questionable; Ames unit: 1 specimen each from locs. Aa-59 and MUu-2; Brush Creek unit: 78 specimens from loc. Cma-3, 7 specimens from loc. MEco-1, 4 specimens from loc. Ale-35; Columbiana unit: 13 specimens from loc. Mg-2, 4 specimens each from locs. Mg-6 and Ss-5, 3 specimens from loc. Cuc-3, 2 specimens each from locs. Cs-9, Mg-7, and Ss-6, 1 specimen each from locs. Cp-3, Cs-3, and Muc-1; Gaysport unit: 1 specimen from loc. No-5; Lower Mercer unit: 1 specimen from loc. Hfg-5; Putnam Hill unit: 11 specimens from loc. Ms-3, 2 specimens from loc. Mc-2, 1 specimen each from locs. Mg-4, Tg-1, Tsc-3, and Vel-15; Upper Mercer unit: 1 specimen from loc. Twy-2; Washingtonville unit: 8 specimens from loc. CAr-2, 1 specimen from loc. Ty-5.

Repository.—Hypotypes, OSU 18704 to 18706, 18740 to 18742, 19556, 19680, 29261, 29311, 29321, 29326, 29328 to 29345, 29422, 29426, 30613, 30614.

Mooreoceras tuba (Girty), 1911
Pl. 1-4, figs. 8, 10, 12, 13

Orthoceras tuba Girty, 1911, p. 142-143; 1915, p. 224-225, pl. 26, figs. 1-4.

Mooreoceras tuba Miller, Dunbar & Condra, 1933, p. 90-92, pl. 2, figs. 2-4; Unklesbay, 1962, p. 27-28, pl. 1, figs. 12, 13; Windle, 1970, p. 49-51, pl. 1, fig. 14.

Diagnosis.—*Mooreoceras* distinguished by abruptly expanded adoral extremity of body chamber of presumably mature individuals.

Material.—There are available 11 fragmentary specimens of this unique species. Nine specimens are from the Washingtonville unit in Ohio, one specimen of questionable identity is from the Brush Creek unit in Ohio, and another is from the Ames unit near Dent, West Virginia. With one exception, each of the Washingtonville specimens is a mostly or completely exfoliated portion of a body chamber, several of which show a septal surface at the apical end, and most of which have a widely flaring but incomplete orad extremity. The exception is a preserved section of phragmocone 10 mm long that has been polished lengthwise to show details of septa and siphuncle. The longest of the specimens has a preserved length of 22.5 mm. Other larger specimens have conch diameters ranging from 7 mm to more than 10 mm and incomplete flare diameters of several additional millimeters. The Ames specimen is a much larger individual and consists of a portion of a body chamber 35 mm long and of one camera 3 mm long; H = 18 mm and W = 20 mm at its apical end; H = 22 mm and W = 24 mm at its orad extremity. The approximate H/W ratio is 0.9.

Description.—Conch small to medium sized, slender, orthoconic, gradually and regularly expanded at an approximate angle of 8°; apertural margin of presumably mature body chamber rapidly expanded, having an estimated expansion angle of almost 50°; conchal cross section slightly depressed, forming a subcircular to subelliptical outline; margin of aperture not observed. Test quite thin, estimated to be less than 0.5 mm thick on most specimens; surface ornament not observed, but reported to be very fine, nearly transverse but slightly sinuous growth lines (Miller, Dunbar, and Condra, 1933, p. 90). Internal mold smooth except for sutures and a tiny, low, longitudinal, midventral line indicating presence of a faint conchal furrow. Sutures nearly transverse to conchal axis, slightly sinuous on largest specimen (OSU 29325), having slight dorsal and ventral lobes and equally slight lateral saddles; septa nearly uniform saucer-shaped discs almost transverse to axis of conch, slightly extended orad across venter on some specimens; on polished specimen (OSU 29323) only moderately and fairly uniformly convex apicad; this specimen shows more convexity dorsoventrally than laterally; septa closely spaced, four to six in a distance equal to conchal diameter; siphuncle located ventrad to center, ratio is 1:2 or 1:3, cyrtochoanitic; septal necks short, definitely recurved; connecting rings not observed but shown by Miller, Dunbar, and Condra (1933, pl. 2, fig. 4) to be subglobular; no cameral or siphuncular deposits observed or reported.

Remarks.—The rapidly expanding apertural portion of the body chamber is unique among known species of *Mooreoceras*. The small size and the closely spaced septa are normal for most individuals. Although the latter two features are not unique, they are characteristic of the species. Our tentatively identified specimen from the Ames unit is unusual in that its diameter is approximately three times the maximum diameter of our other specimens. This large specimen does have a flared aperture that may show the outline of part of the peristome, including a hyponomic sinus (pl. 1-4, fig. 8).

Previous investigators (Girty, 1915, p. 224; Miller, Dunbar, and Condra, 1933, p. 91; Unklesbay, 1962, p. 28) of this species have observed that conchal expansion occurred either in the phragmocone or in the body chamber. We have observed rapid expansion only at the margin of the body chamber and believe that rapid expansion of the conch probably is a feature of mature conchs. If rapid expansion and flaring of the phragmocone did occur, two different stages in diameter of the conch, connected by the rapidly expanded stage, ought to occur. We have not found such expansion in any of our specimens. If this feature does occur, there would be problems in regard to body growth and size. We suspect that any rapid expansion and flare of the phragmocone are apparent rather than real and were caused by mashing and distortion of the conchs during fossilization.

Occurrence.—11 specimens total; Ames unit: 1 questionable specimen from loc. WV:Pr-1; Brush Creek unit: 1 questionable specimen from loc. Cma-3; Washingtonville unit: 5 specimens from loc. CSv-1, 2 specimens each from locs. CSv-4 and MUmu-1.

Repository.—Hypotypes, OSU 29244, 29322 to 29325.

Genus *Poterioceras* M'Coy?, 1844

Type species: *Orthocera fusiformis* Sowerby, 1829; SD, Foerste, 1924

Poterioceras M'Coy, 1844, p. 10; Foord, 1898, p. 43-45, pl. 15, figs. 1a-3; Foerste, 1924, p. 254-255, pl. 40, fig. 2; pl. 41, figs. 1A, B; 1926, p. 330-331, pl. 46, figs. 3, 4A, B; Miller, Dunbar & Condra, 1933, p. 65-68, fig. 14; Miller & Owen, 1934, p. 198-199; Sweet, 1964, p. K314, fig. 224, 5a-d.

Brachycycloceras Furnish, Glenister & Hansman, 1962, p. 1345-1347, fig. 1A (in part); Furnish & Glenister, 1964, p. K232-K233, figs. 162A, B, 163, 1 (in part); Windle, 1970, p. 25-28 (in part).

Cherokeeoceras Windle, 1973, p. 201-206.

Diagnosis.—Large, rapidly expanded, exogastric, cyrtoconic brevicones having circular, subelliptical, or subtrapezoidal whorl sections; dorsal long profile sigmoidal, concave along adapical part of phragmocone and convex over adoral part and body chamber; ventral profile convex; aperture oblique with forward ventral margin; dorsal surface of body chamber having inward-thickened transverse ridge. Test moderately thick, surface marked by growth lines in early growth stages and by smooth mature surface; siphuncle excentric, cyrtochoanitic.

Remarks.—The generic position of Pennsylvanian representatives referred to *Poterioceras* is uncertain. The type species of that genus is from Lower Carboniferous limestone in Ireland. Miller, Dunbar, and Condra (1933, p. 67) stated that specimens occur in the Devonian and Mississippian strata of Europe and North America. Miller and Owen (1934, p. 199) were the first to recognize specimens of *Poterioceras* in the Pennsylvanian. Similar-appearing older Paleozoic forms probably do not belong to the same genus as the specimens under consideration.

In 1962, Furnish, Glenister, and Hansman (p. 1341-1347) presented rather convincing evidence that certain annulated orthocones referred to *Brachycycloceras* and other annulated but rapidly expanded cyrtoconic brevicones variously placed in *Poterioceras* and other genera were immature and mature stages, respectively, of a single deciduous genus, which they concluded should be referred to *Brachycycloceras*. Windle (1973, p. 91-93, 203-204) observed that the rapidly expanded cyrtoconic Pennsylvanian forms, such as *Poterioceras curtum* (Meek & Worthen) and *P. subellipticum* Miller & Unklesbay, placed in *Brachycycloceras* by Furnish and others (1962) were not deciduous and do not have a decollated immature stage. If his observations are true, these two species are not representatives of the genus *Brachycycloceras* and a new genus may need to be established for these rapidly expanded breviconic forms. There is, however, still some question on Windle's determinations. Because there is a diversity of opinion, and because our Ohio material is not adequate for establishment of a new genus, we are provisionally assigning our two species to *Poterioceras* as a matter of convenience. We are also uncertain as to the correct familial position for these forms. We are confident that Furnish and others' (1962) assignment to their family Brachycycloceratidae is incorrect. We are likewise hesitant to accept Windle's approval of Ruzhencev and Shimansky's family Scyphoceratidae until the generic identity is resolved. Again as a matter of convenience, we place them in Foord's family Poterioceratidae. Pennsylvanian representatives of *Poterioceras* are known from Missouri, Oklahoma, and Texas in the Midcontinent region, from Illinois in the Eastern Interior Basin, and from Ohio and Pennsylvania in the Northern Appalachian Basin.

Geologic range.—Mississippian?-Pennsylvanian.

Poterioceras curtum (Meek & Worthen, 1860)

Pl. 1-41, figs. 1-5; pl. 1-42, figs. 4-6; pl. 1-43, fig. 4

Cyrtoceras curtum Meek & Worthen, 1860, p. 468.

Cyrtoceras? *dilatatum* Meek & Worthen, 1860, p. 468-469; 1866, p. 389, pl. 29, fig. 2.

Cyrtoceras (*Aploceras*) *curtum* Meek & Worthen, 1861, p. 148; 1866, p. 388-389, pl. 30, figs. 1a-c.

Cyrtoceras curtum Raymond, 1910, p. 146, 156, pl. 25, fig. 6; pl. 26, fig. 8; 1911, p. 86-87, 96, pl. 4, figs. 3, 4.

Poterioceras curtum? Sturgeon, 1937, p. 358.

Poterioceras curtum Miller & Unklesbay, 1942b, p. 128-130, 133-135, pl. 2, figs. 1-3; pl. 5, fig. 1; 1947, p. 319.

Poterioceras sp. aff. *P. curtum* Sturgeon, 1946, p. 12, 17-18, pl. 3, figs. 1-4.

Cherokeeoceras spp.? Windle, 1973, p. 278-285, figs. 39, 40.

Diagnosis.—Large, cyrtoconic, rapidly expanded, subquadrate to subpyramidal brevicones having surface marked by transverse, low, annular, straplike ridges separated by narrower furrows; ornamentation becoming evanescent orad.

Material.—There are 16 specimens available from the Putnam Hill, Columbiana, and Washingtonville units of the Allegheny Group and from the Brush Creek unit of the Conemaugh Group. Raymond (1910, 1911) and Miller and Unklesbay (1942b, 1947) have reported and illustrated specimens from the Brush Creek and Ames units of western Pennsylvania. Our largest specimen (OSU 28818, pl. 1-41, figs. 1, 2) is a flattened one that has a length of 120 mm, which is undoubtedly extended by distortion and mashing. Preserved lengths of other specimens, all of which are incomplete at both ends, range from less than 40 mm to 70 mm. A relatively undeformed specimen has a preserved approximate length of 40 mm, a width of 35 mm across the sides, 40 mm across the venter, and almost 50 mm across the dorsum near the smaller end. Crushed specimens 250 mm long in which the ventral margin of the aperture extends orad were reported by Furnish, Glenister, and Hansman (1962, p. 1351) from Desmoinesian strata near Knoxville, Iowa.

Description.—Conch large, slightly cyrtoconic, rapidly expanded, subquadrate to subpyramidal, breviconic; whorl section definitely depressed and subtrapezoidal in outline, flattened flanks converging somewhat ventrad; broadly rounded dorsum and venter, dorsum more broadly rounded than venter; dorsolateral and ventrolateral shoulders obtusely rounded, maximum whorl diameter near dorsolateral shoulders (fig. 1-5). Test variable in thickness, normally 2 to 3 mm thick, surface marked by numerous, transverse, deep, narrow furrows separated by broad, flat-topped ridges; spacing of furrows and width of ridges variable, ranging on one specimen from 0.32 mm near larger end to 0.47 mm near smaller end, and a maximum of 1.42 mm between preserved extremities; closer spacing of furrows on dorsum and flanks in part due to intercalation of furrows below dorsolateral shoulders and in part to orad extension of ventral salient; transverse markings broadly convex orad on venter, oblique apicad on ventrolateral shoulders, transverse across sides, slightly oblique on dorsolateral shoulders, and weakly concave orad or nearly straight on dorsum; surface markings evanescent orad on largest specimens. Details of septa and siphuncle not preserved or visible in most specimens; observed septal spacing ranging from 2.5 to 5 mm apart or about one-eighth of dorsoventral diameter, septa moderately convex apicad; slightly sinuous sutures nearly transverse to conchal axis, forming a broad shallow saddle across venter, a smaller but similar lobe on and above ventrolateral shoulders, a similar saddle on and below dorsolateral shoulders, and a nearly straight line across dorsal surface; siphuncle not observed.

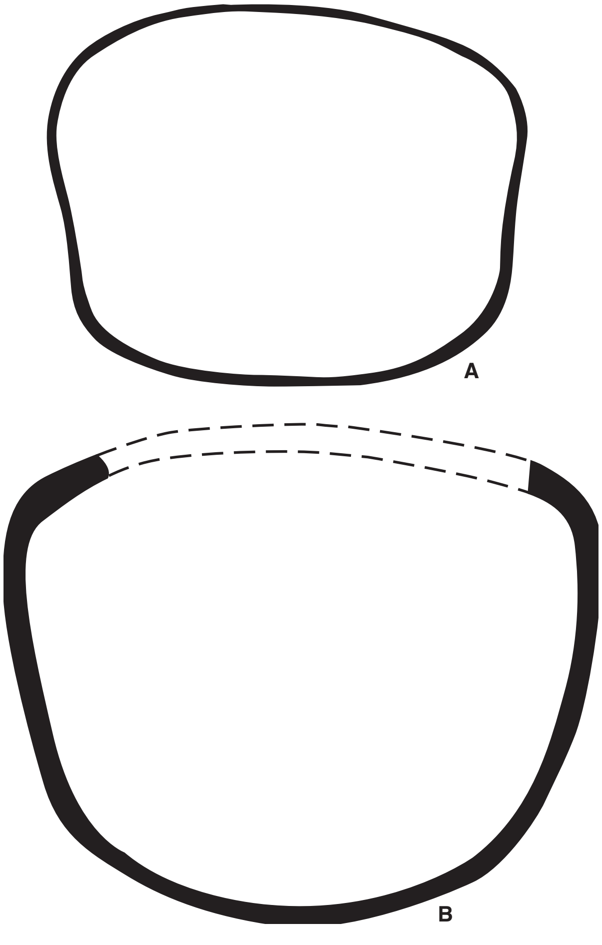


FIGURE 1-5.—*Poterioceras curtum* (Meek & Worthen). Diagrammatic conchal cross sections of two incomplete specimens showing subtrapezoidal outlines of the conches; X $^1/_3$. Both figures after Windle (1973).

A, Putnam Hill unit, loc. Ms-3; OSU 28819 (also see pl. 1-41, fig. 4).

B, Columbiana unit, loc. Mg-7; OSU 18746 (also see pl. 1-41, figs. 3, 5).

Remarks.—*Poterioceras curtum* can be recognized by its large size, rapid expansion, subquadrate to subpyramidal cyrtoconic conch, mature subtrapezoidal whorl cross section (fig. 1-5), and distinct annular surface markings. *Poterioceras subellipticum*, which Furnish and others (1962, p. 1349) considered a synonym of *P. curtum*, has a subelliptical whorl section (see fig. 1-6). We believe that each is a distinct and valid species.

The small Brush Creek specimen (CMNH 3879, pl. 1-42, fig. 5) differs from our other specimens and has a more rounded whorl section. It may represent *P. subellipticum* or even another species, but we suspect that its small size may explain its more rounded cross section.

Occurrence.—16 specimens total; Brush Creek unit: 1 doubtful specimen from loc. Cma-3; Columbiana unit: 2 specimens from loc. Mg-2, 1 specimen each from loc. Mg-6 and Mg-7; Putnam Hill unit: 3 specimens from loc. Mg-4, 2 specimens from loc. Mg-3, 1 specimen each from locs. Mc-1, Ms-3, Td-4, and Vel-15; Vanport unit: 1 specimen from loc. Tl-1; Washingtonville unit: 1 specimen from loc. Ty-2.

Repository.—Hypotypes, OSU 18703, 18745 to 18747, 19555, 28818, 28819; doubtful hypotypes, CMNH 3879, SUI 34792.

Poterioceras subellipticum Miller & Unklesbay, 1942
Pl. 1-42, figs. 1, 2; pl. 1-43, figs. 1, 2

Poterioceras subellipticum Miller & Unklesbay, 1942b, p. 135-136, pl. 2, fig. 4, pl. 4, fig. 4; Sturgeon, 1946, p. 12, 16-17, pl. 4, fig. 1.

Brachycycloceras curtum Furnish, Glenister & Hansman, 1962, p. 1349-1351 (in part).

Diagnosis.—Large cyrtoconic brevicones having a depressed subelliptical whorl section.

Material.—Only two specimens are known: the holotype (UNSM IP8341) from the Argentine Limestone Member of the Wyandotte Formation near Louisville, Nebraska, and a questionable hypotype (OSU 18702) from the Vanport unit at Bolivar in Tuscarawas County, Ohio. We have had opportunity to study both specimens. Neither specimen is complete at either end; approximate measurements on preserved portions of the conchs are given below.

holotype (UNSM IP8341):

preserved conchal length = 160 mm

maximum whorl width = 115 mm
whorl height near mid-length = 55 mm
whorl width near midlength = 85 mm
whorl height at preserved adapical end = 18 mm
whorl width at preserved adapical end = 30 mm

hypotype (OSU 18702):

preserved length of phragmocone = 85 mm
preserved length of body chamber = 40 mm
whorl height at contact of body chamber and phragmocone = 55-60 mm
whorl width at contact of body chamber and phragmocone = 75 mm

The holotype is more complete, has some test and surface ornament preserved, and appears to be only slightly distorted. The less complete questionable hypotype is exfoliated and somewhat mashed dorsoventrally.

Description.—Conch large, cyrtoconic, breviconic, subconic in shape, rather rapidly expanded in size throughout; exogastric curvature restricted to apicad portions of conch, remainder straight or nearly so; preserved part of dorsum longitudinally concave, venter convex; whorl cross section depressed, nearly elliptical (fig. 1-6), broadly rounded dorsally and ventrally; ventral surface somewhat more convex than dorsal side; flanks more narrowly rounded than dorsum and venter. Test thin, preserved only on right side and partially across dorsum on holotype, apparently less than 1 mm thick; marked by broad, strong, slightly asymmetrical bands about 1 mm wide and separated by narrow furrows; bands slightly sinuous, extending in a slight re-entrant across dorsum. Features of internal mold only visible on hypotype; mold apparently smooth except for sutures and a broad, shallow transverse constriction on dorsal side of body chamber about 25 mm orad of last suture; full width not preserved, body chamber destroyed laterally, ventrally, and orad of constriction. Sutures preserved only on orad portion of phragmocone; last four septa spaced 8, 11, and 15 mm apart toward living chamber, indicating an immature individual; ratio of septal spacing to present width of conch approximately 6:1; sutures possibly a little distorted from original pattern, slightly sinuous, having a small obliquity orad toward dorsum and showing a midventral shallow, rounded lobe; lobe flanked on each side by a corresponding ventrolateral saddle and beyond by an asymmetrical, shallow, rounded lobe and an apicad trend across dorsolateral zones to join nearly straight course across dorsum to form a very broad, shallow dorsal saddle; nature and position of siphuncle unknown.

Remarks.—There is some question concerning the specific identity of these two specimens. Miller and Unklesbay described and named the Nebraska specimen in 1942 (1942b, p. 135-136), and Sturgeon identified the Ohio specimen as a representative of the species in 1946 (p. 16-17). In 1962, Furnish, Glenister, and Hansman (p. 1349) placed both specimens in the synonymy of *Brachycycloceras curtum* (Meek & Worthen) in the belief that their subelliptical cross sections were the result of distortion during fossilization. The Ohio specimen is somewhat distorted, but even so it shows no evidence of any original subtrapezoidal cross section. Distortion is less likely for the Nebraska specimen, which is preserved in firm limestone. The cross sections of the holotype of *Poterioceras subellipticum* shown in figure 1-6 are subelliptical in outline throughout the entire length of the preserved conch and lack any tendency for flattened surfaces. Undistorted specimens referred to *P. curtum* (Meek & Worthen) have subtrapezoidal cross sections and definite ventrolateral flattened areas converging ventrad (see fig. 1-5). It is our interpretation that two distinct species are represented.

Occurrence.—2 specimens total; Argentine Limestone Member, Wyandotte Formation: 1 specimen from loc. N:Cl-1; Vanport unit: 1 specimen from loc. Tl-1.

Repository.—Holotype, UNSM IP8341; doubtful hypotype, OSU 18702.

Genus *Tainoceras* Hyatt, 1883

Type species: *Nautilus quadrangulus* McChesney, 1860; OD

Tainoceras Hyatt, 1883, p. 269; Miller, Dunbar & Condra, 1933, p. 145-148, pl. 10, fig. 6; Miller & Youngquist, 1949, p. 80-81, pl. 11, fig. 11; Kummel, 1964, p. K413, fig. 298, 5a, b; Windle, 1970, p. 51-52.

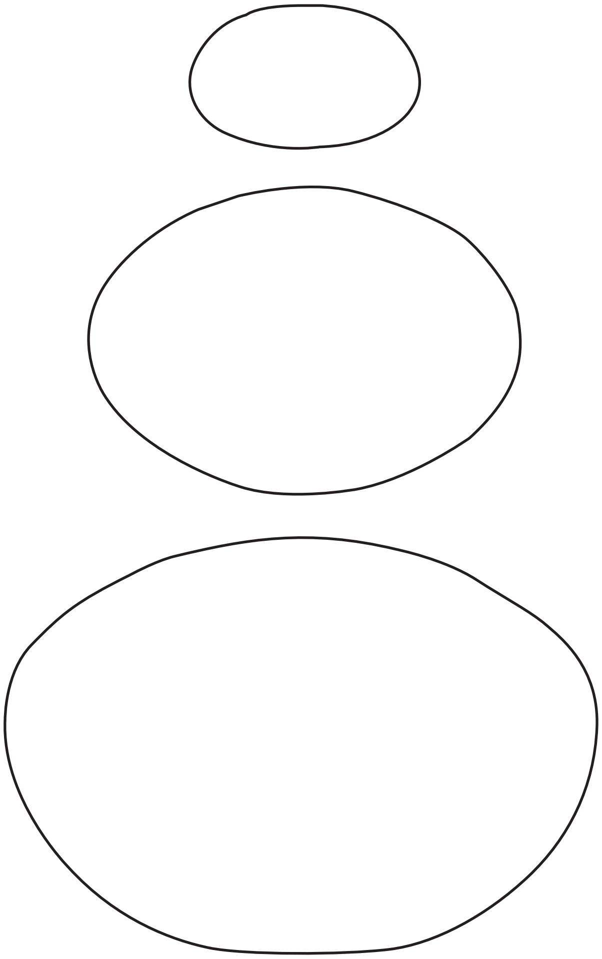


FIGURE 1-6.—*Poterioceras subellipticum* Miller & Unklesbay. Three diagrammatic subelliptical cross sections based on the conch of the holotype at 22, 48, and 70 mm, respectively, from the tip of the preserved apical end; X1; Argentine Limestone Member of Wyandotte Formation, loc. N:Cl-1 (Nebraska); UNSM IP8341 (also see pl. 1-42, figs. 1, 2).

Diagnosis.—Similar to *Metacoceras* but possessing two ventral longitudinal rows of nodes or ribs separated by a median sulcus.

Description.—Conch medium sized to medium-large, tarphyceraconic to weakly nautiliconic, umbilicus wide and open; whorl section subquadrate to subrectangular (see fig. 1-7D); venter moderately convex, two midventral longitudinal rows of nodes or oblique ribs separated by a median ventral sulcus; ventrolateral shoulders and commonly umbilical shoulders having a single row of nodes, ventrolateral ones commonly larger; surface ornament consisting of growth lines or a reticulate pattern; septa and sutures nearly transverse to whorl, septa moderately convex and sutures somewhat sinuous; siphuncle orthochoanitic, ventrad in position.

Remarks.—*Tainoceras* certainly evolved from earlier tainoceratids that have a conch similar to that of *Metacoceras*. *Tainoceras* is readily differentiated from *Metacoceras* and other tainoceratids by possession of a longitudinal ventral row of either nodes or ribs on each side of a median sulcus. Although *Tainoceras* ranges from the lower part of the Upper Pennsylvanian into the Triassic and is widely distributed geographically, it is limited in numbers and distribution in Ohio to a few fragmentary specimens from several localities of the Ames and Portersville units (Mark, 1912; Windle, 1970). In North America, Pennsylvanian specimens of *Tainoceras* also have been reported in the Appalachian region from Maryland (Price, 1920; Lintz, 1958), Pennsylvania (Raymond, 1910, 1911; Miller and Unklesbay, 1942b), and West Virginia (Meek, 1871a); in the Illinois Basin (McChesney, 1860); in the Midcontinent region (Miller, Dunbar, and Condra, 1933); and in Wyoming (Miller and Thomas, 1936). Miller and Youngquist (1949) reported Permian examples in the United States from the Midcontinent region, the Southwest, and the Rocky Mountain region and foreign occurrences from southern Europe, the former Soviet Union near Moscow and in Siberia, and India. The scarcity and the fragmentary and variable nature of our specimens have made systematic consideration of this genus difficult.

Geologic range.—Pennsylvanian-Triassic.

Tainoceras collinsi Sturgeon, Windle, Mapes & Hoare, 1982

Pl. 1-5, figs. 1, 2, 4

Tainoceras occidentale Raymond (*non* Swallow), 1910, p. 147-149, 156, pl. 27, fig. 7; 1911, p. 90, 92, 93, 96, pl. 6, fig. 7.
Tainoceras monilifer Miller & Unklesbay, 1942b, p. 129-130, 142-143 (in part), pl. 4, fig. 3.
Tainoceras n. sp. Windle, 1970, p. 58-60, pl. 2, figs. 12, 13.
Tainoceras collinsi Sturgeon, Windle, Mapes & Hoare, 1982, p. 1454-1455, pl. 1, figs. 5, 9.

Diagnosis.—A species of *Tainoceras* characterized by nearly paired ventrolateral nodes; two rows of unpaired, weak, closely spaced, adorally oblique, ventral ribs separated by a well-developed median sulcus; small, closely spaced umbilical nodes.

Material.—We have only three fragmentary specimens in our collection: the holotype (OSU 28826) from the Ames shale near Morgantown, West Virginia, and two paratypes (OSU 30732) from the Ames in Jefferson County, Ohio. Another specimen (CM 149), identified by Raymond (1910, 1911) as *Tainoceras occidentale* and later by Miller and Unklesbay (1942b, pl. 4, fig. 3) as *T. monilifer*, is tentatively assigned to this species. The holotype, consisting of about one-third whorl, includes at least one camera, portions of two septa, and possibly a large part of the living chamber. Approximate measurements on the preserved parts of the conch are: distance along the venter = 90 mm; H (at midlength) = 27 mm, W (at midlength) = 36 mm, H/W = 0.75; umbilicus large, U/D = 0.50, probably perforate.

Description.—Conch medium sized to medium-large, moderately expanded growth, tarphyceraconic; whorl section subrectangular; venter moderately convex, broad median sulcus and discontinuous concavities on each side adjacent to ventrolateral nodes; median sulcus progressively less distinct orad and separating two irregular rows of unpaired, indistinct, closely spaced (20 estimated on one half whorl) adorally oblique ribs, which disappear rather abruptly orad at midlength on the holotype; ventrolateral shoulders obtuse, moderately rounded, large paired longitudinally elongate nodes extending part way across whorl's side and spaced approximately eight per one-half volution; lateral walls otherwise flat and slightly convergent ventrad; umbilical shoulders obtuse, more narrowly rounded than ventrolateral shoulders, bearing a row of numerous, small, closely spaced (estimated 12 per one-half volution), variously shaped nodes having steep umbilical slopes, inclined slightly toward umbilicus. Test moderately and quite uniformly thick, estimated to be 1 to 2 mm thick except possibly in nodes; surface marked by numerous closely spaced, distinct growth lines indicating a broad hyponomic sinus and following nearly straight courses across lateral and dorsal surfaces. Septa and sutures only partially preserved and somewhat distorted; septa moderately and unevenly convex apicad, sharply convex across whorl near dorsum, slightly oblique and ventral margin extended orad; suture pattern sinuous and typical for genus, having a broad symmetrical ventral lobe, broad asymmetrical lateral lobes, and narrower umbilical and ventrolateral saddles; siphuncle circular in outline, approximately 2 mm in diameter at passage through a septum, slightly ventrad in position, 6 mm above venter and 8 mm below dorsum.

Remarks.—*Tainoceras* sp. #1 (see p. 30 and pl. 1-5, fig. 6) and *T. unklesbayi* Miller & Youngquist are most like *T. collinsi* in the possession of somewhat similar ventral oblique ribs, but *T. unklesbayi* differs from those species in having much weaker ribs and smaller, more numerous, more closely spaced umbilical nodes. *Tainoceras collinsi* is intermediate between *Tainoceras* sp. #1 and *Tainoceras* sp. #2 (see p. 31 and pl. 1-5, figs. 7, 9) in respect to strength of ventral ribs, but its numerous small umbilical nodes are distinct from the large and more widely spaced nodes of *Tainoceras* spp. #1 and #2. The differences in umbilical nodes among these three species, and the time difference for *T. unklesbayi*, suggest that they may be examples of parallel development rather than of straight-line evolution. The specific name is given in appreciation of Horace R. Collins, former State Geologist and Chief of the Ohio Division of Geological Survey, who collected the holotype.

Occurrence.—4 specimens total; Ames unit: 2 specimens from loc. JEwa-3; 1 specimen each from locs. PA:Ap-1 and WV:Mm-1.

Repository.—Holotype, OSU 28826; two paratypes, OSU 30732; CM 149.

Tainoceras marylandicum (Lintz, 1958)

Pl. 1-5, figs. 3, 5, 8

Tainoceras monilifer Miller & Unklesbay, 1942b, p. 142-143 (in part), pl. 4, fig. 2.
Metacoceras marylandica Lintz, 1958, p. 97, 100, 104, pl. 16, figs. 22, 24.
Tainoceras marylandica Windle, 1970, p. 53-56, pl. 2, figs. 5-9.

Diagnosis.—A species of *Tainoceras* characterized by two rows of unpaired, rounded ventral nodes separated by a shallow sulcus; unpaired, blunt, elongate ventrolateral nodes; unpaired, well-developed, rounded nodes on umbilical shoulders; distinctive reticulate shell surface.

Material.—This species was originally based on specimens from the Ames limestone of Maryland and is also known from the same unit in Pennsylvania and West Virginia. Our collection has only two fragmentary Ohio specimens from the Ames in Muskingum County that are tentatively referred to this taxon. We also have three, more complete and positively identified specimens and a fragment of the venter of a tentatively identified specimen, all from the Ames unit in Garrett County, Maryland. One Ohio specimen (OSU 28822) consists of about one-third of a whorl and has preserved portions of the lateral and umbilical surfaces including three ventrolateral and four umbilical nodes. The other specimen is only a mere fragment of the side and umbilical walls and includes one umbilical node and two ventrolateral nodes. The three larger Maryland specimens, consisting approximately of one or more volutions each, are fragile, preserved in shaly matrix, exfoliated or partially destroyed on one side, and more or less distorted. The largest specimen (OSU 28824) and the one (OSU 29327) preserved as only a fragment of the venter show traces of the reticulate surface pattern. Another of the larger specimens (OSU 28823) exposes partial remains of two septal surfaces and one cameral chamber, as well as several partial sutures. Maximum diameter of the largest specimens exceeds 70 mm, and umbilical diameters are less than half the conch diameters; U/D ratios = 0.40 to 0.45. At midlength, whorl dimensions of one specimen that has a diameter of 65 mm are: H = 27 mm, W = 34 mm, and H/W ratio = 0.80.

Description.—Conch medium sized, tarphyceraconic to slightly nautiliconic, dorsum weakly impressed; umbilicus less than half of conch's diameter, steep walled, moderately deep, probably perforate; whorl section depressed, subrectangular; venter convex, having a rather shallow median sulcus or median flattened zone on mature living chamber; noded ventrolateral shoulders slightly obtuse and rather abruptly rounded; sides relatively flat and slightly convergent ventrad; noded umbilical shoulders slightly obtuse and more broadly rounded than ventrolateral shoulders; umbilical wall steep and nearly parallel to axis of coiling; middorsum slightly impressed. Test moderately thick (approximately 2 mm) on venter and lateral walls, much thicker in nodes and in umbilical and ventrolateral shoulders; surface ornament a reticulate pattern formed by conspicuous, wavy, longitudinal and transverse lirae; venter divided into three approximately equal longitudinal areas by two rows of numerous (11 on a half volution) circular to slightly elongate, short, blunt, unpaired nodes on areas sloping slightly dorsad, separated by a shallow sulcus; margin of these nodes indistinct toward adoral margin; ventrolateral shoulders obtuse and rather abruptly rounded, each bearing a row of blunt, longitudinally elongate, laterally directed, alternating nodes spaced so that nine occur on a half volution; ventral surface of larger nodes having shallow cuspate depressions; umbilical shoulders obtuse, narrowly rounded, and possessing a row of weaker, rounded nodes so spaced that eight occur on a half volution. Septa possibly distorted, strongly and rather evenly convex, convexity 5+ mm at a whorl height of 20+ mm, or ratio of 1:4; siphuncle eccentric, ventrad, nearer venter than center, and approximately 2 mm in diameter at septum, other details unknown; sutures incompletely preserved, sinuous, marginal traces of broad, shallow dorsal and ventral lobes; shallow lateral lobe and ventrolateral and umbilical saddles.

Remarks.—Except for the Ohio specimens, all specimens under consideration agree with Lintz's holotype (USNM 119254) which we have had opportunity to study. We first observed that his holotype was a representative of *Tainoceras* instead of *Metacoceras*, as indicated by the two rows of ventral nodes separated by a median sulcus. Lintz's paratype (USNM 119255) lacks the diagnostic ventral nodes, but it probably represents an adoral portion of a living chamber of a mature specimen, as does one of our fragmentary Maryland specimens (OSU 29327; pl. 1-5, fig. 3).

The unique feature of *Tainoceras marylandicum* appears to be the reticulate ornament on the venter, but unfortunately this feature can easily be obscured or overlooked. There are several other species of *Tainoceras* that resemble the species under consideration; these can be distinguished by the following features:

T. clydense Miller & Kemp—umbilical nodes more weakly developed;
T. monilifer Miller, Dunbar & Condra—ventrolateral nodes paired, ventral nodes in part transversely elongate;
T. nebrascense Miller, Dunbar & Condra—umbilical nodes more weakly developed;
T. nodocarinatum (McChesney)—questionably no umbilical nodes, whorl wide, nearly twice the height;
T. rotundum Miller, Dunbar & Condra—no umbilical nodes, ventral nodes longitudinally elongate;
T. wyomingense Miller & Thomas—ventral and ventrolateral nodes more closely spaced, ventrolateral nodes smaller.

The fragmentary condition and the nature of preservation of the two Ohio specimens permit only tentative reference to this species. Their ventrolateral nodes are smaller and more elongate than those of *Tainoceras* sp. #1, and their umbilical nodes are too large and too far apart for *T. collinsi* Sturgeon, Windle, Mapes & Hoare. Their preservation does not retain any of the distinctive reticulate surface pattern.

Occurrence.—9 specimens total; Ames unit: 5 specimens from loc. MD:GTc-1; 2 specimens (Lintz's types) from loc. MD:Ams-1; 2 tentatively referred specimens from loc. MUu-2.

Repository.—Holotype, USNM 119254; paratype, USNM 119255; hypotypes (one doubtful), OSU 28822 to 28824, 29327.

Tainoceras sp. #1

Pl. 1-5, fig. 6

Diagnosis.—A doubtful species of *Tainoceras* distinguished by large transversely elongate umbilical nodes and large longitudinally elongate ventrolateral nodes, very weak or obsolescent ventral nodes or ribs, and a weak ventral sulcus.

Material.—A single, slightly distorted internal mold consisting of slightly less than half a whorl is the only available specimen; it is from the Ames unit. Its approximate dimensions are: preserved distance along outer curvature of whorl = 125 mm; D = 80+ mm; U = 30 mm; U/D = 0.38; H (est.) = 30 mm; W (est.) = 33 mm; H/W (approx.) = 0.90. Traces of at least a half dozen camerae are indistinctly preserved at the adapical end. The remainder of the conch was presumably part of the living chamber.

Description.—Conch medium sized to large, tarphyceraconic, moderately expanded; whorl subrectangular in cross section, venter weakly convex, a broad, shallow median sulcus bordered toward apicad end by very weak, nearly transverse ribs extending laterally to ventrolateral nodes; ventrolateral shoulders obtuse, rather narrowly rounded, and bearing paired, large, blunt, longitudinally extended nodes spaced eight to a half volution; whorl sides nearly straight but definitely concave below crests of umbilical and ventrolateral nodes; umbilical shoulders also obtuse, more broadly rounded than ventrolateral shoulders, marked by approximately six large, blunt nodes elongated onto whorl sides; umbilical wall steep, sloping somewhat inward toward axis of coiling; features of inner whorls and umbilicus not adequately preserved for observation. Septa and sutures also poorly preserved, but broad ventral and lateral lobes and narrower and sharper saddles apparent on ventrolateral and umbilical shoulders.

Remarks.—It was with some hesitation that this specimen was identified as *Tainoceras*, because its ventral ribs and nodes are very weak and hardly discernible. Its general configuration, ventral sulcus, and well-developed umbilical and ventrolateral nodes, however, indicate that it is a member of that genus. It can readily be separated from all other species of *Tainoceras* by its faint ventral ribs and the large H/W ratio of its whorl. Our specimen does resemble *Tainoceras collinsi*, which differs in the possession of numerous, small, closely spaced umbilical nodes.

Occurrence.—1 specimen; Ames unit: loc. Aa-47.

Repository.—OSU 28825.

Tainoceras sp. #2

Pl. 1-5, figs. 7, 9

Tainoceras monilifer Sturgeon and associates, 1958, pl. 10, fig. 11.

Tainoceras cf. *T. unklesbayi* Windle, 1970, p. 56-58, pl. 2, fig. 10.

Diagnosis.—A species of *Tainoceras* characterized by two longitudinal rows of unpaired, adorally oblique ventral ribs separated by a moderately deep median sulcus; rounded ventrolateral nodes more widely spaced than the ventral ribs; and even more widely spaced indistinct umbilical nodes.

Material.—This species is represented by one incomplete specimen and two fragments of questionable identity from the Ames unit. The incomplete specimen (OSU 28821) is approximately one-third of the outer volution of an internal mold and consists of five camerae of the phragmocone bounded by a partially preserved septum and a portion of the body chamber. Its length along the midventer is approximately 80 mm, its whorl height and width at midlength are 25 and 30 mm, respectively, and the H/W ratio is approximately 0.70. The two questionable fragments (OSU 29241) consist of small exfoliated ventral portions of the body chamber and phragmocone.

Description.—Conch medium sized, tarphyceraconic to weakly nautiliconic, subdiscoidal, apparently moderately and evenly expanded; umbilicus moderately large, having a probable diameter of over 30 mm at an estimated conch diameter of 75 mm and an approximate U/D ratio of 0.40; whorl section moderately depressed and subquadrate in outline; venter broadly rounded and divided by a medium to deep midventral sulcus separating two rows of closely spaced, noded, adorally oblique, unpaired ribs (30 estimated on outer volution), best developed at midlength and becoming less distinct toward adoral margin of living chamber; ventrolateral shoulders slightly obtuse, broadly rounded, bearing a row of large, blunt, rounded, widely spaced, unpaired nodes (seven estimated on half of outer volution); lateral walls nearly flat, converging slightly ventrad; umbilical shoulders also slightly obtuse but more narrowly rounded than ventrolateral shoulders and bearing a few subdued, rounded, widely spaced nodes; dorsum obscured by matrix but apparently slightly impressed. Visible external sutures sinuous, consisting of a broad ventral lobe, narrowly rounded ventrolateral saddles somewhat modified by position of nodes, shallow lateral lobes, and narrowly rounded umbilical saddles; remainder of suture pattern and features of septa and siphuncle not visible.

Remarks.—Windle (1970, p. 57) compared our largest specimen with *Tainoceras unklesbayi* Miller & Youngquist, which it somewhat resembles. Our specimen differs from that species not only in age, but also in having smaller umbilical nodes and ventral ribs, closer spacing of those ribs and the ventrolateral nodes, a steeper umbilical wall, and a narrower whorl section. It is uncertain whether the resemblance is an example of parallel development or whether our specimen might represent the ancestral line that led to *T. unklesbayi*. Details of size and spacing of ribs and nodes distinguish the specimens under consideration from *T. collinsi* Sturgeon, Windle, Mapes & Hoare and *Tainoceras* sp. #1.

Occurrence.—3 specimens total; Ames unit: 2 questionable specimens from loc. MUu-2; 1 specimen from loc. Ad-13.

Repository.—OSU 28821, 29241.

Genus *Metacoceras* Hyatt, 1883

Type species: *Nautilus (Discus) sangamonensis*
Meek & Worthen, 1860; OD

Metacoceras Hyatt, 1883, p. 268-269; Girty, 1915, p. 239-240; Miller, Dunbar & Condra, 1933, p. 166-170; Miller & Youngquist, 1949, p. 104-105; Kummel, 1953, p. 19-20; 1964, p. K414, fig. 297, 2; Gordon, 1964, p. 142; Windle, 1970, p. 60-62; Sturgeon, Windle, Mapes & Hoare, 1982, p. 1455.

Foordiceras Hyatt, 1893, p. 392-393; Miller & Youngquist, 1949, p. 96-97 (in part); Kummel, 1953, p. 17-19 (in part).

Diagnosis.—Small to medium-sized tainoceratids commonly characterized by variable subquadrate to subrectangular whorl sections having ventrolateral nodes, and, on some species, umbilical nodes and transverse lateral ridges.

Description.—Conch small to medium sized, tarphyceraconic, moderately evolute at maturity; umbilicus wide, open, and perforate; mature whorl section variable, commonly subquadrate to subrectangular but less commonly subhexagonal, subpentagonal, or subtrapezoidal; nodes on ventrolateral shoulders, less commonly on umbilical shoulders,

FIGURE 1-7.—Diagrammatic cross sections of adult whorls of several species representing selected nautiloid genera. All genera represented are found in Ohio, but only the species in 7E and 7K have been found in Ohio. Figures 7C-F, H, and I appear to be based on internal molds. All figures are approximately X1 except as noted.

A, *Temnocheilus coronatus* M'Coy. Depressed subelliptical whorl cross sections of distorted hypotype showing inward lateral and umbilical surfaces; Middle Viséan limestone, loc. Eim-1, England (Isle of Man); JW 1441. After Turner (1954).

B, *Endolobus* sp. B Gordon. Subelliptical cross section of apicad chamber of fragmental specimen; Hale Formation, Kessler Mountain, Washington County, Arkansas; USNM 119692. After Gordon (1964).

C, *Domatoceras umbilicatum* Hyatt. Compressed subtrapezoidal cross section of ultimate whorl of holotype; Cherokee Formation, Oswego, Kansas; USNM 23870. After Hyatt (1891) and Miller and Owen (1934).

D, *Tainoceras wyomingense* Miller & Thomas. Composite cross section of ultimate whorl based on two syntypes; Casper Formation, Gilmore Canyon southeast of Laramie, Wyoming; SUI 1159, 1163. After Miller and Thomas (1936).

E, *Mahoningoceras pottsvillense* (Morningstar). Equidimensional subtrapezoidal cross section of ultimate whorl near body chamber of holotype; Lower Mercer unit, loc. Lh-1, OSU 8995 (also see pl. 1-21, figs. 3, 5, 6). After Morningstar (1922).

F, *Metacoceras sangamonense* (Meek & Worthen). Equidimensional subrectangular cross section of a whorl of a topotype; X2; McLeansboro Group, Sangamon County, Illinois; repository and catalog number unknown. After Miller and Owen (1934).

G, *Metacoceras carinatum* Girty. Subrectangular whorl cross section of a paratype; X2; Wewoka Formation, station 2004, Coalgate quadrangle, Oklahoma; USNM 120704. After Girty (1915) and Kummel (1953).

H, *Temnocheilus* sp. Miller & Owen. Subelliptical cross section of a specimen showing inward sloping lateral and umbilical surfaces; Strawn Group near Millsap, Texas; YPM, catalog number unknown. After Miller and Owen (1934).

I, *Metacoceras nodosum* Miller, Dunbar & Condra. Equidimensional rectangular cross section of holotype; X $^{2}/_{5}$; Kansas City Formation, Kansas City, Missouri; YPM 13994. After Miller, Dunbar, and Condra (1933).

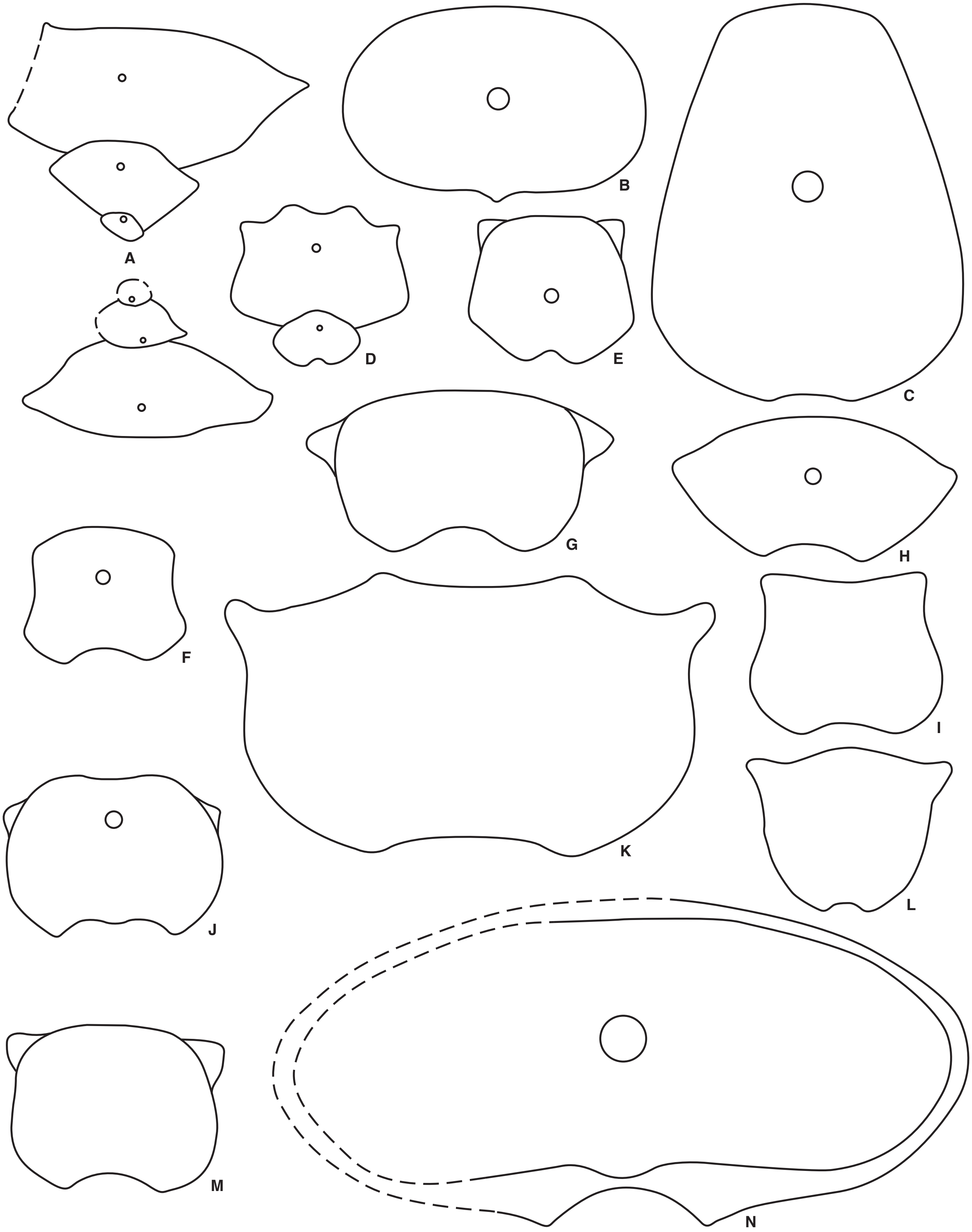
J, *Metacoceras dubium* Hyatt. Subrectangular cross section of whorl (probably of holotype), X $^{2}/_{3}$; Pennsylvanian?, Kansas; repository and catalog number unknown. After Hyatt (1891) and Kummel (1953).

K, *Latitemnocheilus latus* (Meek & Worthen). Subrectangular cross section of ultimate whorl of holotype; Seville Limestone, loc. IL:Rih-1 (Illinois); UI X-438A. Modified from Kummel (1953).

L, *Metacoceras sinuosum* Girty. Subtrapezoidal whorl cross section of holotype; X2; Wewoka Formation, station 2005, Wewoka quadrangle, Oklahoma; USNM 120706. After Girty (1915) and Kummel (1953).

M, *Metacoceras cornutum* Girty. Subrectangular cross section of holotype; X1$^{1}/_{4}$; Wewoka Formation, station 2001, Coalgate quadrangle, Oklahoma; USNM 120702. After Girty (1915) and Kummel (1953).

N, *Endolobus clorensis* Collinson. Subelliptical whorl cross section of a hypotype; X$^{1}/_{2}$; Fayetteville Formation, USGS loc. 15075, Middle Fork of White River, Washington County, Arkansas; USNM 119797. After Gordon (1964).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nodes possibly connected across flanks by transverse ribs; nodes and ribs normally reduced or obsolete on outer mature whorl; septa and sutures nearly transverse to conchal axis; sutures slightly sinuous, normally having shallow dorsal, lateral, and ventral lobes and saddles at umbilical and ventrolateral shoulders and at umbilical seams; siphuncle small, subcentral in position, and orthochoanitic.

Remarks.—The genus *Metacoceras* as now interpreted has a wide range in diversity of conch and whorl form and of ornament. In general, the mature whorl section is variable and can be considerably depressed (figs. 1-7F, G, I, J, L, M). Coiling is normally tarphyceraconic; the umbilicus is large, open, and perforate. The ventrolateral and umbilical shoulders are abruptly rounded to subangular, the latter more prone to rounding; the ventrolateral shoulders are nodose and rarely carinate, and lateral ribs and/or dorsolateral nodes or carinae may be present. Nodes and ribs tend to decrease in size and to disappear on adult body chambers.

The holotype of the type species, *Metacoceras sangamonense* (Meek & Worthen), is an internal mold and is characterized by a subrectangular whorl section (fig. 1-7F), ventrolateral nodes, and distinctly concave lateral walls without any visible lateral or dorsolateral ornament. If the genus were strictly interpreted, *Metacoceras* representatives would lack carinae, nodes, and ribs on flanks and dorsolateral shoulders at least on mature whorls. As indicated above, such is not the present interpretation of the limits for species within the genus. The diversity of presently included forms indicates that a thorough restudy and evaluation of the genus and its species are in order.

Miller and Youngquist (1949, p. 96-97), in considering the genus *Foordiceras* Hyatt, made several taxonomic changes in genera and species. They placed several genera in synonymy with *Foordiceras*, including *Parametacoceras* Miller & Owen, and transferred a number of Permian species from *Metacoceras* to *Foordiceras*. Kummel (1953, p. 17-19) did not agree with much of their interpretation, as most of the species assigned by them to *Foordiceras* have subquadrate whorl sections and nodes or spines. *Nautilus goliathus* Waagen, the type species of *Foordiceras*, possesses a subtrapezoidal whorl section in which the flanks slope uninterrupted from the ventrolateral region in to the umbilicus. The flanks also bear robust transverse ribs that end at the ventrolateral shoulders, well below the umbilicus, without any development of nodes or spines. On the basis of these features of the type species of *Foordiceras*, we agree with Kummel in the rejection of most of Miller and Youngquist's transfers to that genus.

Metacoceras has more species than any other genus of Pennsylvanian and Permian coiled nautiloids. Kummel (1953, p. 20) listed 47 species in these systems in North America and Eurasia. Some of those species are now placed in other genera, and several additional species have been named and described. In the United States, *Metacoceras* is widely distributed in marine units of the Pennsylvanian and Permian Systems (Miller, Dunbar, and Condra, 1933, p. 167-168; Miller and Unklesbay, 1942a, p. 719-726; Miller, 1945, p. 282-283; Unklesbay, 1954, p. 88-90).

In the region covered by the present study, *Metacoceras* representatives have been described from several units of the Pottsville, Allegheny, and Conemaugh Groups. Mark (1912, p. 279, 281, 285, 299) reported specimens of *Metacoceras* from the Ames and Portersville units of the Conemaugh Group. Morningstar (1922, p. 144, 269-270) listed and described three specimens from Pottsville marine units of southern Ohio, but we are referring one of these to the genus *Mahoningoceras* Murphy, and the others actually came from the Putnam Hill unit (Allegheny Group). Sturgeon (1937, p. 358, 1946, p. 12, 24-28) and Sturgeon and Miller (1948, p. 77) described representatives from the Allegheny and Conemaugh Groups. Windle (1970, p. 62-72) described two previously undescribed species, now named *M. mcchesneyi* Murphy and *M. clinocostatum* Sturgeon, Windle, Mapes & Hoare, from Conemaugh marine units. Murphy (1970, p. 198-201) listed and described several species of *Metacoceras*, including the new species *M. mcchesneyi*, from Allegheny and Conemaugh marine strata. The present report describes and summarizes data on all known species of *Metacoceras* from Ohio—a possible total of 12 species.

Raymond (1910, p. 156; 1911, p. 83, 96) reported *Metacoceras sangamonense* (Meek & Worthen) from the Vanport unit of western Pennsylvania. Miller and Unklesbay (1942b, p. 128-130, 139-142; 1947, p. 322) described a host of specimens from the Conemaugh Group of western Pennsylvania. Swartz, Price, and Bassler (1919, p. 578) listed representatives of *Metacoceras* from the Ames and Brush Creek units of Maryland. Chow (1951, p. 7, 10, 35) listed but did not illustrate *M. sangamonense* (Meek & Worthen) from the Mill Creek limestone (Conemaugh Group) near Wilkes- Barre, in the anthracite region of Pennsylvania.

Geologic range.—Pennsylvanian-Permian.

Metacoceras clinocostatum Sturgeon, Windle, Mapes & Hoare, 1982
Pl. 1-8, figs. 4-9

Metacoceras perelegans Miller & Unklesbay, 1942b (non Girty, 1911), p. 141-142, pl. 1, figs. 8-10, pl. 3, figs. 6-8; Sturgeon and associates, 1958, pl. 10, fig. 1; Murphy, 1970, p. 198-199 (in part), pl. 35, fig. 6.

Metacoceras n. sp. B Windle, 1970, p. 68-72, pl. 4, figs. 1-6.

Metacoceras clinocostatum Sturgeon, Windle, Mapes & Hoare, 1982, p. 1455-1458, pl. 1, figs. 4, 8, table 1.

Diagnosis.—Small to medium-sized species of *Metacoceras* characterized by depressed mature whorls; rounded ventrolateral and umbilical shoulders; closely spaced, oblique, transverse costae on flanks, becoming reduced adorally and developing into obliquely elongate ventrolateral nodes and dorsolaterally transverse elongate nodes or ribs.

Material.—There are approximately 120 incomplete and imperfectly preserved specimens of this species from the Putnam Hill, Vanport, Brush Creek, and Cambridge units in our collection. Most specimens are less than a single whorl, partially or wholly testiferous, and more or less crushed laterally. Condition of these specimens prevents determining accurate and complete measurements for any of them; the limited dimensions and ratios in table 1-4 are based on the holotype and four paratypes. It is estimated that our largest specimens may have had a conch diameter of 40 mm, but Miller and Unklesbay (1942b, pl. 3, fig. 6) illustrated a partial specimen, which we have accepted with some hesitation, that has an approximate diameter of 70 mm. If all of these represent the same species, it is likely that most or all of our specimens are immature. Our most complete specimens have only a little more than two whorls, but we suspect that a complete adult conch may have had three or more whorls.

Description.—Conch small to medium sized, tarphyceraconic, subdiscoidal; umbilicus moderately wide, deep,

TABLE 1-4.—*Conch measurements and ratios of* Metacoceras clinocostatum

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	H/W	U/D
OSU 28971-A (holotype)	17	8				0.47
OSU 28971-B (paratype)			10	15	0.66	
OSU 28972 (paratype)	25	9				0.34
OSU 28974 (paratype)			8	12	0.65	
OSU 28999 (paratype)			8	12	0.65	

NOTE: The measurement and ratio abbreviations for tables 1-4 to 1-24 are explained on page 2.

weakly gradate, perforate, U/D ratios ranging approximately between 0.35 and 0.50; whorl profile depressed, maximum width apparently between umbilical shoulders, H/W ratio approximately 0.65; venter moderately and evenly convex except for tendency toward a median flattening on some specimens; flanks rather narrow, true nature obscured by numerous transverse costae, apparently slightly convergent ventrad; ventrolateral and umbilical shoulders rounded except at transverse ribs; transverse ribs numerous, closely spaced (18 to 24 per whorl), extending obliquely downward and orad, continuing into elongate, oblique ventrolateral nodes and terminating gradually dorsad or in nodes near umbilical shoulders; considerable variation among nodes and ribs on certain specimens; umbilical walls slightly convex, sloping rather steeply inward toward conchal axis, elevated at umbilical seams by thickening of shell; dorsal surface narrower than umbilical walls, impressed 0.8 mm at an impression width of 4.5 mm and a whorl width of 13.5 mm. Test thin (less than 1 mm thick); surface ornament in addition to costae and nodes consisting of indistinctly preserved fine growth lirae outlining a rather deep, rounded, flaring ventral sinus, a shallow concave orad pattern on flanks, and a nearly straight course across umbilical walls. Septa and sutures not well exposed; septa nearly transverse to whorl axis, slightly farther orad dorsally, more strongly convex dorsoventrally than laterally; siphuncle not clearly observed, apparently slightly ventrad of center on a smaller paratype (OSU 28974); sutures only slightly sinuous, having a very shallow, rounded ventral lobe, a slight lobe or straight course across umbilical walls, and probably a dorsal lobe.

Remarks.—There is some variation in ribs and nodes among various individuals. In specimen OSU 28975 from the Brush Creek unit near Summitville, in Columbiana County, part of the ribs disappears in a manner that forms a threefold development of nodes. Another specimen, OSU 29131, from the Vanport unit in Vinton County, has developed a row of nodes on the flanks rather than at or near the umbilical terminations of the ribs. On other specimens, represented by one of the paratypes (OSU 28971-B, pl. 1-8, fig. 9), the ventrolateral nodes tend to be rounded and to become less distinct orad. Another variation occurs on several fragments of larger individuals (OSU 28975, 29136) which have angular shoulders where the ribs have disappeared; nodes present on both shoulders are similar to those on the adoral portion of the conch of *Metacoceras perelegans* Girty.

Specimens from the Brush Creek unit have been identified by Miller and Unklesbay (1942b, 1947) and by Murphy (1970) as *Metacoceras perelegans* Girty. Girty's species has more angular shoulders and fewer and generally robust lateral ribs directed nearly perpendicular to the axis of coiling. A number of species of *Metacoceras* that have transverse lateral ridges and dorsolateral and ventrolateral nodes are listed with salient features under the remarks for *M. perelegans*. Here we need only to compare Young's (1942) three species referred to *Huanghoceras* from the Magdalena Group of New Mexico and Hansman and Miller's *Foordiceras danvillense* (Hansman, 1958) from the McLeansboro Group at Danville, Illinois.

Young's specimens of *Huanghoceras collinum, H. obliquicostatum*, and *H. percostatum*, which we have observed, are not only incomplete but also much distorted. It is impossible to ascertain measurements necessary to determine ratios or to make other pertinent observations on these specimens. In our broad interpretation of the genus *Metacoceras* we would place all three of his species in that genus. *Metacoceras collinum*, which has nodeless or weakly noded transverse lateral ribs, appears to be distinct. *Metacoceras obliquicostatum* and *M. percostatum* (now *M. bryani* Young, 1945, p. 319) may be the same species within which size differences and individual variations provided the basis for their separation. If they do prove to be the same and a distinct species, *M. obliquicostatum* has page priority. These two species, which have oblique lateral ribs and rounded ventrolateral nodes, resemble *M. decoratus* (Cox), and we are inclined to refer them to Cox's species (Cox, 1858). They differ from our specimens in having rounded instead of diagonally elongate ventrolateral nodes and apparently more angular umbilical shoulders.

As far we know, *Foordiceras danvillense* (Hansman, 1958, p. 211-212, pl. 21, figs. 6, 7) is a *nomen nudum*. We have seen this specimen and would also refer it to *Metacoceras*. The type specimen (SUI 13674) for that proposed species is a fairly complete and well-preserved individual that has oblique transverse lateral ribs and no nodes on its rather sharply rounded umbilical shoulders. The specimen has a narrow whorl (H/W ratio = 0.78), a very definite flattened area along the midventer, numerous longitudinal lines along the venter, and less oblique lateral ribs. We believe that this specimen probably represents a distinct species intermediate in form between *M. perelegans* and *M. clinocostatum*. Prior to our examination of Young's 1942 report and specimens, we were proposing *M. obliquicostatum* as the name for our specimens.

Occurrence.—120 specimens total, several questionable; Brush Creek unit: 102 specimens from loc. Aa-41, 5 specimens from loc. Aw-51, 3 specimens each from locs. Aa-53 and Cfr-1, 1 specimen from loc. Ad-32; Cambridge unit: 1 specimen from loc. Gwe-1; Putnam Hill unit: 3 specimens from loc. MUho-9, 1 specimen from loc. Ty-3; Vanport unit: 1 specimen from loc. Vel-20.

Repository.—Holotype, OSU 28971-A; paratypes, OSU 28899, 28900, 28971-B, 28972, 28974, 28975, 29131 to 29136, 30611, USNM 161411.

Metacoceras lambi Sturgeon, 1946

Pl. 1-6, figs. 1-3

Metacoceras lambi Sturgeon, 1946, p. 12, 26-27, pl. 6, figs. 9-11.

Diagnosis.—Medium-sized *Metacoceras* having a rather strongly depressed whorl cross section and a midventral sulcus.

Material.—The holotype (OSU 18721), consisting of about one-fourth of a testiferous whorl 35 mm in length, is the only known specimen of this species. The complete conch is estimated to have had a maximum diameter of approximately

45 mm. The following measurements were taken near the orad end of the specimen: H = 14.8 mm, W = 22.9 mm, W/D = 0.51, H/W = 0.61.

Description.—Conch medium sized, tarphyceraconic, subdiscoidal; umbilicus wide, deep; whorl section much depressed dorsoventrally, subhexagonal to subrectangular in shape; venter slightly convex, actually biconvex, with a very shallow and very broad trough bearing a sulcus approximately 1 mm wide and a little less deep along its midline; flanks flattened, marked by transverse ridges and converging ventrad, maximum whorl width between dorsolateral shoulders; umbilical walls convex on both exterior and internal mold, dorsum weakly impressed (1.5 mm deep and 9 mm wide); ventrolateral and umbilical shoulders and umbilical seams obtusely angular, shoulders less so on internal mold because of test thickening. Test thin, less than 0.5 mm in ventral, lateral, and umbilical walls, and approximately 1 mm thick in dorsolateral and ventrolateral shoulders; both of these shoulders ornamented by a single row of nodes, those on ventrolateral shoulders being larger, 5 or 6 mm apart, obliquely elongate in same direction as whorl's axis, extended outward and downward, and forming a longitudinal concavity on each side of venter; nodes on umbilical shoulders about 4 mm apart, conical or elongated across flanks along connecting plications, and intermediate in height between ventrolateral nodes and connecting plications; nodes of two shoulders normally connected by plications, some plications discontinuous, others slightly concave orad; test ornamented by fine growth lines fasiculated at intervals into stronger but rather inconspicuous lirae, deflected sharply apicad just within ventrolateral nodes to trace outline of a broad rounded ventral sinus, nearly straight or oblique apicad over flanks, and slightly convex orad across umbilical walls. Only one septum and its suture partially preserved and exposed; septum nearly transverse, moderately and evenly convex apicad; suture slightly sinuous, forming broad ventral and lateral lobes and a smaller rounded ventrolateral saddle; other features of suture and those of siphuncle indeterminate.

Remarks.—This species resembles *Metacoceras perelegans* Girty and *M. latum* Sturgeon, Windle, Mapes & Hoare, but differs from both of them in having a midventral sulcus, and from the former in having a more transverse whorl section. *Metacoceras sulciferum* Miller & Thomas from the Casper Formation of Wyoming (Miller and Thomas, 1936) has a somewhat similar venter, but has no pronounced subrectangular sulcus along its midventral groove, has fewer and more definitely longitudinally oblique nodes, a less rapidly expanded whorl, and possibly less convex dorsolateral surfaces. The specific name commemorates the late Professor George F. Lamb, who for many years was an inspiring teacher of geology at Mount Union College, Alliance, Ohio.

Occurrence.—1 specimen; Columbiana unit: loc. Mg-2.

Repository.—Holotype, OSU 18721.

Metacoceras latum Sturgeon, Windle, Mapes & Hoare, 1982

Pl. 1-6, figs. 4-19

Metacoceras latum Sturgeon, Windle, Mapes & Hoare, 1982, p. 1458-1460, pl. 1, fig. 6; pl. 2, figs. 4, 5.

Diagnosis.—Medium-sized *Metacoceras* having a low, wide whorl section marked by dorsolateral and ventrolateral nodes indistinctly connected across the flanks by irregular ridges at early stages of growth.

Material.—There are approximately 80 specimens referred to this species, of which a number were identified with some reservation. Most specimens were collected from the Washingtonville unit, although a small number are from the Columbiana unit and a doubtful one is from the Brush Creek unit. These specimens are all incomplete; the most complete consist of no more than a third of a single whorl. A dozen specimens are essentially undistorted; preserved lengths along the venter, whorl heights and widths, and H/W ratios for a number of them are listed in table 1-5. Casual inspection of these measurements and ratios indicates an approximate average ratio of whorl height to width of 0.61. The whorls of the largest specimens are more depressed and transverse than those of smaller specimens. Lack of preservation of the inner whorls leaves details of the early growth stages unknown.

TABLE 1-5.—*Conch measurements and H/W ratios of* Metacoceras latum

Specimen	L (mm)	H (mm)	W (mm)	H/W
OSU 28892[1] (paratype)	25	8.1/10.0	12.4/16.4	0.60
OSU 28898 (paratype)	22	14.7	25.8	0.57
OSU 28910 (paratype)	27	8.7	13.9	0.625
OSU 28911 (paratype)	27	14.5	23.4	0.62
OSU 28913[1] (holotype)	46	12.7/15.4	19.9/21.2	0.64/0.58

[1] Two measurements (adapical and adoral) on same specimen.

Description.—Conch medium sized to large, tarphyceraconic; umbilicus moderately wide, deep, steep walled, and presumably perforate; mature whorls depressed, much wider than high, more rapidly expanded in width than in height; whorl cross section imperfectly subhexagonal, broadly convex with a flattened median zone ventrally, flattened across rather narrow ventrally converging flanks marked by irregularly transverse ridges, and concave below crests of dorsolateral and ventrolateral nodes, slightly convex and steep across umbilical walls; dorsum moderately impressed (at least 2 mm deep on largest specimens), dorsal impression a little narrower than umbilical walls and approximately one-third of whorl width. Test a little more than 1 mm thick under all surfaces and thicker beneath shoulders and umbilical seam and in nodes; surface marked by nearly transverse, fine growth lines on lateral and umbilical surfaces; lines unequal in size and outlining a broad, shallow, tongue-shaped hyponomic sinus on venter; ventrolateral shoulders ornamented by bluntly rounded, somewhat elongate, nonconfluent nodes (estimated 25 to 30 per whorl) that have irregular elongations onto flanks except on adoral parts of largest specimens; umbilical shoulders also marked by smaller, bluntly rounded nodes, only slightly elongate onto flanks and spaced about midway between ventrolateral nodes. Septa and sutures not preserved on most specimens; exceptions are OSU 28896 and 28912; septa moderately convex apicad and distinctly farther orad dorsally; suture having distinct dorsal and ventral lobes, faint lateral lobes, weak saddles at ventrolateral and umbilical shoulders, and a stronger saddle at umbilical seam; siphuncle unknown except for its slightly ventrad position and small diameter at septa.

Remarks.—*Metacoceras latum* is another species that has nodes on both the umbilical and ventrolateral shoulders. Comparison among the several species with two rows of nodes on each side of adult whorls is given under the description of *M. clinocostatum* Sturgeon, Windle, Mapes

& Hoare on p. 34 and of *M. perelegans* Girty on p. 40. *Metacoceras latum* resembles *M. biseriatum* Miller & Owen, the types of which were available for observation. Some of the *M. biseriatum* specimens are large and have wide but somewhat higher whorls, a similar shallow, widely flaring ventral sinus, and similar nodes, but seemingly have more definite transverse ridges. The specimens representing our largest *M. latum* individuals (for example, OSU 28917) are more transverse and have narrower sides than the largest specimen of *M. biseriatum*. The whorl at the apical end of the holotype of *M. biseriatum* has approximate dimensions of 12.5 mm in height, 17.5 mm in width, and a H/W ratio of almost 0.73. Our specimens of similar size have H/W ratios between 0.58 and 0.63. *Metacoceras perelegans* does not resemble the specimens under consideration as much as *M. biseriatum* and differs in having a narrower whorl section, average H/W ratios between 0.65 and 0.70, a deeper and narrower hyponomic sinus, and some differences in features and arrangement of nodes and transverse ridges.

Occurrence.—79 specimens total, several doubtful; Brush Creek unit: 1 specimen from loc. Aa-41; Columbiana unit: 6 specimens from loc. Msp-2, 4 specimens from loc. Msp-1, 1 specimen from loc. Mg-2; Washingtonville unit: 28 specimens from loc. Car-2; 15 specimens from loc. Ty-5, 12 specimens from loc. MUmu-1, 4 specimens each from locs. CSv-1 and CSv-4, 2 specimens each from locs. CSf-1 and Ss-3.

Repository.—Holotype, OSU 28913; paratypes, OSU 28892, 28895 to 28898, 28910 to 28912, 28914 to 28917, 29262, 29263.

Metacoceras mcchesneyi Murphy, 1970

Pl. 1-7, figs. 1-12

Nautilus sp. McChesney?, 1868, pl. 3, fig. 6.

Metacoceras cornutum Girty, 1911, p. 145-146 (in part); 1915, p. 240-242, pl. 29, figs. 4-4b (in part); Miller & Unklesbay, 1942b, p. 139-141, pl. 3, figs. 1-5; 1947, p. 322, pl. 1, figs. 9, 10; Sturgeon & Miller, 1948, p. 77.

Temnocheilus winslowi Raymond?, 1910, p. 156; 1911, p. 86, 88, 90, 96.

Metacoceras sangamonensis Price, 1918, p. 788, 801-802, pl. 44, fig. 6.

Metacoceras n. sp. A Windle, 1970, p. 62-68, pl. 4, figs. 7-18.

Metacoceras mcchesneyi Murphy, 1970, p. 199-201, pl. 35, figs. 1-5.

Diagnosis.—*Metacoceras* characterized by a wide subtrapezoidal whorl cross section in mature stage, a broad, moderately shallow hyponomic re-entrant, and closely spaced, large, blunt, slightly ventrally projecting ventrolateral nodes.

Material.—Our collection consists of over 340 specimens. Miller and Unklesbay (1942b, 1947) reported 72 specimens, and Murphy (1970) reported over 160 specimens. Our largest specimen has a maximum conch diameter of approximately 65 mm; Miller and Unklesbay (1947) and Murphy (1970) report maximum conch diameters of 80 and 85 mm, respectively. Miller and Unklesbay (1947, pl. 1, figs. 9, 10) illustrated a fragmentary specimen from the Ames limestone that must have had a diameter in excess of 90 mm. The measurements and ratios in table 1-6 are based upon the holotype, two paratypes, and several hypotypes and topotypes. Extremes and averages for the several ratios are: W/D ratio extremes = 0.56/0.73, average = 0.70; H/W ratio extremes = 0.54/0.81, average = 0.67; U/D ratio minimum = 0.21/0.36, average = 0.29; U/D ratio maximum = 0.34/0.49, average = 0.43. Variations among these measurements and ratios are dependent on such factors as individual variations; growth stage, especially changes in conch and whorl shapes; loss or retention of shell; and distortion during fossilization.

Description.—Conch medium sized to large, tarphyceraconic, subdiscoidal to subglobose, rapidly expanded and more evolute toward aperture of largest individuals; umbilicus moderately wide to wide and perforate; perforation wide, short, and comma shaped; apicad end of conch blunt and nearly circular in cross section, elliptical between one-half and end of first whorl, H/W ratio approximately 0.67; whorl cross section becoming subtrapezoidal to subpentagonal adorally, maximum width between dorsolateral shoulders; venter convex, more so on earlier and intermediate whorls, flattened along a broad median zone bordered on each side by a wide, rounded ridge; flanks and umbilical walls also flattened, the latter slightly convex and sloping steeply inward; dorsum impressed, occupying little more than one-third of whorl width (approximately 14.5 mm

TABLE 1-6.—*Conch measurements and ratios of* Metacoceras mcchesneyi

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
USNM 161406 (holotype)	57	24	21	33.6	0.64	0.62	0.46
USNM 161408 (paratype)	67	27	29				0.41
USNM 161410 (paratype)		13	24.2		0.54		
SUI 3118[1] (hypotype)	59	19.0/27.5[2]	25.5	38	0.64	0.67	0.32/0.46[3]
SUI 3118[1] (hypotype)	74	34/33[2]	30	50	0.67	0.60	0.32/0.44[3]
SUI 13637 (hypotype)	63	17/25[2]	27	42	0.66	0.64	0.27/0.40[3]
OSU 28921 (topotype)	54	19.5/23[2]	24.5	39.5	0.73	0.62	0.36/0.43[3]
OSU 28923 (topotype)	39	16.5	18	24.5	0.63	0.73	0.42
OSU 28924 (topotype)	48.5	14.5/21.7[2]	22	27	0.56	0.81	0.30/0.44[3]
OSU 28927 (topotype)	34.5	11/17[2]	14.5	20.2	0.58	0.71	0.32/0.49[3]
OSU 28928 (topotype)	60.8	25	24	34	0.56	0.71	0.41
OSU 28929 (topotype)	41.8	11.5/17[2]	19.7	26	0.62	0.76	0.21/0.41[3]
OSU 28933 (topotype)	10.9	2.6	4.7	6.4	0.59	0.73	0.24
OSU 28934 (topotype)	61.5	18/27[2]					0.29/0.34[3]

[1] More than one specimen with same catalog number.

[2] Minimum and maximum diameters.

[3] Minimum and maximum ratios.

wide and 3 mm deep at a whorl width of 41 mm); exfoliated angles at ventrolateral and umbilical shoulders and at umbilical seams obtuse, widest at umbilical seams and narrowest at ventrolateral shoulders, these angles more narrowly rounded exteriorly on shell-bearing specimens, especially at slightly elevated umbilical shoulders and definitely elevated umbilical seams. Test variable in thickness among individuals and on same large individual, ranging from 1 mm in venter and thinnest part of flanks to 2 mm in dorsum, 2+ mm in umbilical seams, 3 to 4 mm in umbilical shoulders, and even greater in ventrolateral nodes; surface ornament consisting of universal coverage of fine growth lirae, more obvious and of two sizes on larger specimens, and of lateral ribs and ventrolateral nodes on parts of surface; earliest whorl surfaces marked only by fine growth lirae tracing a wide, shallow, rounded ventral sinus; lirae slightly inclined apicad across lateral surface and nearly transverse across dorsal surface; on mature portions of conch, ventral growth lirae similar to those of earliest whorl, but becoming concave apicad just below ventrolateral nodes, convex across nodes, and nearly straight across internodal areas, forming a shallow sigmoid pattern with an orad convexity above ventrolateral shoulders, a concavity above and across umbilical shoulders, and a low orad convexity across umbilical wall; low, rounded transverse ribs obliquely slanted adorally toward venter on flanks between earliest one-half and one-and-one-third volutions, recognizable but not conspicuous on internal mold; as lateral ribs disappear, low, elongate, almost confluent ventrolateral nodes appear and develop adorally into approximately 16 paired robust protuberances per whorl; in ventral aspect these large nodes project slightly downward, asymmetrical in outline with steep side of node on apicad side; nodes obsolescent orad only on body chambers of largest specimens, much reduced on internal mold. In addition to subdued replicas of nodes and ribs, internal molds marked by a rather faint midventral ridge, indicating a very shallow conchal furrow, and by sutures; septa nearly transverse, extended farther orad dorsally; sutures sinuous, forming shallow, symmetrical, broadly rounded ventral and dorsal lobes and similar but slightly asymmetrical lateral lobes; narrower saddles at ventrolateral shoulders and umbilical seams; siphuncle slightly ventrad in position, orthochoanitic; connecting rings very slightly expanded; septal necks extending approximately one-fourth of distance between two adjacent septa (1 mm in a total of 4 mm) at a whorl's dorsoventral diameter of approximately 18 mm.

Remarks.—This species is the most abundant coiled nautiloid available for study; more than 300 specimens ranging from nearly complete and well preserved to mere fragmentary individuals are on hand. We also had opportunity to observe the pertinent specimens studied by Miller and Unklesbay (1942b, 1947) and by Murphy (1970). Almost all specimens were collected from the Brush Creek unit in an area of Madison Township, Columbiana County. Here in several small strip mines there were literally thousands of specimens in a thanatocoenose. One peculiar feature of these specimens, including the more complete ones, is total or almost total demolition of the septa even to the apicad extremity. Many exfoliated specimens show full details of the suture pattern, but when selected specimens are cut and polished, loss of all or most septa is apparent. Only one sectioned specimen shows a trace of the siphuncle and that only between two adjacent septa (pl. 1-7, fig. 7). Normally the interiors of conchs without septa are filled only with matrix, but a few shells are partially filled with rock pebbles and shells of smaller organisms (pl. 1-7, fig. 10).

We are referring the many specimens in our collection to a single species. There is considerable variation among them, but much can be interpreted as intergrading individual variations affected by age, size, completeness, and manner of preservation. We are also influenced by their occurrence in a single stratigraphic zone mostly at a solitary restricted locality. As shown in the synonymy, this species has previously been referred to several species, but superficially it most nearly resembles *Metacoceras cornutum* Girty from the Wewoka Formation of Oklahoma. Although Girty's species does have large, prominent, and spinelike ventrolateral nodes, it has more parallel flanks, more rounded dorsolateral shoulders, and seemingly a deeper ventral lobe than specimens under consideration here. His specimens are also considerably older than ours; the two groups may represent an example of parallel evolution. Murphy (1970, p. 199) did include part of Girty's specimens (1915, pl. 29, figs. 4-4b) under *M. mcchesneyi* and we are following his opinion.

Some resemblance also is noted to *M. sangamonense* (Meek & Worthen), which possesses distinctly concave flanks and more inclined umbilical walls than our Conemaugh specimens. *Metacoceras mutabile* Miller & Owen from the Desmoinesian Cherokee Formation of Missouri is likewise similar to our specimens, but differs in lacking robust nodes, strongly flaring flanks, steep umbilical walls, and transverse lateral ribs on intermediate growth stages and in having somewhat different conch and whorl ratios. It too is an older species. *Metacoceras mutabile* Miller, Lane & Unklesbay from the Winterset Limestone of Missouri is a junior homonym of *M. mutabile* Miller & Owen and has been renamed *M. simile* by Sturgeon, Windle, Mapes, and Hoare (1982, p. 1460). It possibly resembles *M. mcchesneyi* more than any of the above species, but differs noticeably in having more inclined umbilical walls and more nearly parallel flanks.

We are doubtful of Murphy's citation of McChesney's figured specimen (1868, pl. 3, fig. 6), as McChesney's drawn figure shows transverse ribs opposite the ventrolateral nodes on the apicad portion of his specimen. The occurrence of nodes and ribs on the same area is contrary to our observations of available specimens. There is also some question concerning the inclusion of Raymond's *Temnocheilus winslowi* from Pennsylvania in the synonymy. Both Miller and Unklesbay and Murphy have included his citation. We have been unable to observe Raymond's specimens, but it is likely that Miller and Unklesbay did see them. Raymond's specimens came from the Ames, Brush Creek, and Pine Creek (upper Brush Creek) units, and at least some of them probably represent *M. mcchesneyi*. Price's specimen from Upshur County, West Virginia, appears to be authentic.

Occurrence.—341+ recognizable specimens and fragments; Ames unit: 1 doubtful specimen from loc. Aa-27; Brush Creek unit: 300+ specimens from loc. Cma-3; 35 specimens from loc. Aa-41; Cambridge unit: 1 specimen from loc. Ls-1; Portersville unit: 2 specimens from loc. Aa-12, 1 specimen each from locs. MUha-1 and Pb-1. In addition to our specimens, Murphy (1970) listed 163 specimens from the Brush Creek unit, mostly from loc. Cma-3, as well as 1 specimen from the Portersville unit and 2 possible specimens from the Columbiana unit. Miller and Unklesbay cited 65 specimens (1942b) and 7 specimens (1947) from the Brush Creek, Pine Creek (upper Brush Creek), Woods Run (Portersville), and Ames units from western Pennsylvania, including 1 specimen from the Ames unit of Ohio.

Repository.—Holotype, USNM 161406; paratypes, USNM 161407 to 161410, 163338 to 163342; hypotypes, OSU 19604, SUI 3118, 3120 to 3123, 8173, 13636, 13637; topotypes, OSU 28921 to 28931, 28933 to 28939, 28950, 29242, 29243, 29264, 30609; OSU 28940 to 28943, 28954, plus numerous unnumbered fragmentary specimens; CM 25792 to 25797.

Metacoceras cf. *M. mcchesneyi* Murphy, 1970
Pl. 1-8, figs. 1-3, 16

Metacoceras mcchesneyi Murphy, 1970, p. 199-201, pl. 35, figs. 1-5.

Diagnosis.—Medium-sized *Metacoceras* having depressed subrectangular whorl section, medium-sized ventrolateral nodes, and rather deep, rounded, widely flaring ventral lobes.

Material.—We have a single, medium-sized partially testiferous undistorted specimen of two or more whorls from the Ames unit. The specimen has been cut across the conch to reveal some internal features. The following measurements and ratios are based on measurements in part on the cut surface: D = 51 mm, U = 20.5 mm, H = 18.2 mm, W = 26.3 mm, W/D = 0.52, H/W = 0.70, U/D = 0.40.

Description.—Conch medium sized, tarphyceraconic, subdiscoidal, apparently consisting of three whorls with wide umbilicus; mature whorl section depressed, subrectangular to subpentagonal in outline (pl. 1-8, fig. 3); umbilicus steep walled, gradate, and presumably perforate; venter convex, having a wide, flattened, slightly depressed midzone and steeper slopes adjacent to ventrolateral shoulders; flanks and umbilical walls flattened but slightly convex, flanks convergent ventrad, maximum whorl width between umbilical shoulders, umbilical walls possibly weakly sigmoidal; dorsum depressed, almost 2.5 mm deep and 10 mm wide at a whorl width of 26 mm; earliest preserved whorl not well preserved, but apparently has a subcircular section, intermediate whorl subelliptical in outline, flattening developing on flanks and umbilical walls and impressing of dorsum; ventrolateral shoulders obtuse, broadly rounded except in nodes; umbilical shoulders more narrowly obtuse, subangular on exterior, angles at umbilical seam widely obtuse. Test not well preserved, eroded, very thin, apparently well under 1 mm in thickness except in ventrolateral and umbilical shoulders; surface ornament mostly destroyed but fine growth lines locally preserved, showing traces of a broadly rounded ventral sinus and a sigmoidal pattern on flanks; each ventrolateral shoulder having approximately 20 medium-sized, slightly confluent nodes, asymmetrical in ventral view and having longer orad margins, merging into ventral surface, and bluntly extended onto lateral surfaces; umbilical shoulders raised by thickened shell into a low rounded keel. Internal mold smooth except for traces of a midventral raised line, subdued replicas of ventrolateral nodes and sutures; only ventral suture pattern exposed toward orad end of conch, sutures spaced almost 7 mm apart along midventer, except last two adjacent to body chamber spaced a little less than 5 mm apart, indicating a mature specimen; ventral sutures consisting of a widely flaring, rounded, V-shaped, moderately deep ventral lobe, depth equal to septal spacing, bordered on each ventrolateral shoulder by a more narrowly rounded saddle; no other features of sutures, septa, or siphuncle discernible.

Remarks.—As far as can be ascertained this specimen rather closely resembles *Metacoceras mcchesneyi* Murphy and *Metacoceras* sp. #1 described herein. It differs from *M. mcchesneyi* in having smaller, more numerous ventrolateral nodes per whorl, a much deeper ventral lobe, and possibly a smaller conch; it differs from *Metacoceras* sp. #1 in possessing a more depressed whorl and deeper ventral lobes. Until more and better specimens are available, we prefer not to assign this specimen to a definite taxon, although there is some temptation to consider it as a subspecies of *M. mcchesneyi*.

Occurrence.—1 specimen; Ames unit: loc. MUu-2.

Repository.—OSU 28932.

Metacoceras mutabile Miller & Owen, 1934
Pl. 1-8, figs. 10, 12

Metacoceras mutabile Miller & Owen, 1934 (non Miller, Lane & Unklesbay, 1947), p. 226-229, pl. 16, figs. 1, 2; Murphy, 1970, pl. 36, figs. 1, 2.

Diagnosis.—Small to medium-sized *Metacoceras* having a moderately depressed whorl section, intermediate-sized ventrolateral nodes, and transverse plications with or without dorsolateral nodes.

Material.—In our collection there are eight specimens of *Metacoceras mutabile* Miller & Owen, 1934 (*non M. mutabile* Miller, Lane & Unklesbay, 1947) from the Putnam Hill unit. In addition, we have examined Miller and Owen's (1934) type specimen (SUI 13399) and two specimens (USNM 161414, 161415) illustrated by Murphy (1970, pl. 36, figs. 1, 2). Our most complete specimen (OSU 28893) consists of more than two whorls; our other specimens are each less than half a whorl. Table 1-7 records a few available measurements and ratios. There is some inconsistency in table 1-7 between the U/D ratios of SUI 13399 (the holotype) and OSU 28893. Unfortunately, our other specimens do not enable determination of ratios to permit establishment of a reliable value for this ratio.

Description.—Conch medium sized, gradually expanded, tarphyceraconic, subdiscoidal; adult conchs consisting of a minimum of two-and-a-half whorls; umbilicus deep, wide, steep walled, gradate, and perforate; perforation subelliptical in outline and approximately 3 by 4 mm on an exfoliated specimen (OSU 28893); earliest whorl rounded, intermediate and mature whorls only moderately depressed, H/W ratio approximately 0.80; maximum whorl width between or below umbilical shoulders; whorl cross section subhexagonal; venter moderately convex, median zone flattened to slightly depressed, flanks flattened but concave between the extremities of ventrolateral and umbilical nodes, umbilical walls flattened and slightly sigmoidal, weak concavity adjacent to umbilical shoulders and slight convexity or flattened zone toward umbilical seams; dorsum concave, impressed 1 mm or more, as wide or slightly wider than umbilical walls; ventrolateral and umbilical shoulders narrowly obtuse, angle at umbilical seam more broadly obtuse. Test 0.5 mm to 1 mm thick, thinnest in ventral and umbilical walls, slightly thicker in lateral walls and considerably thicker in shoulders and nodes; surface marked by numerous rather fine growth lirae of two sizes, finer ones only visible on certain areas, particularly on nodes and shoulders; lirae outlining a moderately deep, widely flaring, U-shaped ventral sinus, a broad salient on the flanks, and a nearly straight course across the umbilical wall; nodes and transverse ridges somewhat varied on different specimens, ventrolateral shoulders bearing approximately 20 rather

TABLE 1-7.—*Conch measurements and ratios of* Metacoceras mutabile

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
OSU 28893 (hypotype)	28	15	7	9.7	0.46	0.72	0.54
OSU 28894 (hypotype)			12.9	16.1		0.80	
OSU 28918 (hypotype)			10	12.1		0.83	
USNM 161414 (hypotype)			10	13		0.77	
USNM 161415 (hypotype)			8.2	10.6		0.77	
SUI 13399 (holotype)	37.8	17	15.6	20	0.49	0.80	0.45

small, bluntly rounded or, less commonly, elongate nodes on adult whorls; these nodes tending on some specimens to be definitely elongated across the flanks, terminating in smaller nodes on umbilical shoulders, and on other specimens becoming indistinctly plicated, both plications and umbilical nodes disappearing orad on mature specimens; umbilical shoulders tending to be carinate, and definitely carinate beyond disappearance of nodes on those shoulders. Internal mold marked by a small ridge indicating position of a midventral conchal furrow, by subdued replicas of ventrolateral nodes and transverse ridges, and by sutures; sutures on specimen OSU 28893 indicating an immature specimen having a body chamber more than one-third of outer whorl's length; sutures having broad rounded dorsal, lateral, and ventral lobes, lobes very strong on specimen OSU 2293 and weak on specimen OSU 28894, and saddles at umbilical and ventrolateral shoulders and at umbilical seam; septa evenly and moderately convex apicad, nearly transverse to whorl axis but farther orad dorsally; siphuncle slightly ventrad in position, a little over 1 mm in diameter on specimen OSU 28894; other details not exposed.

Remarks.—We have compared our specimens with Miller and Owen's holotype and believe them to be conspecific. They differ from other binodal species of *Metacoceras* by their less transverse mature whorl sections and by variation in development of nodes and transverse plications. Further comparison is given under remarks for *M. mcchesneyi* Murphy and for *M. perelegans* Girty. In 1947, Miller, Lane, and Unklesbay (p. 8-9, pl. 1, figs. 5-8) described and named another similar but larger species of *Metacoceras* from the Winterset Limestone near Kansas City, Missouri, as *M. mutabile*. Their species is a junior homonym of *M. mutabile* Miller & Owen, 1934 and has been renamed *M. simile* by Sturgeon, Windle, Mapes and Hoare (1982, p. 1460).

Occurrence.—8 specimens total; Putnam Hill unit: 4 specimens from loc. Mc-2, 2 specimens from loc. Mg-4, 1 specimen each from locs. Ms-3 and Ts-1.

Repository.—Holotype, SUI 13399; hypotypes, OSU 2293, 28893, 28894, 28918, USNM 161414, 161415.

Metacoceras perelegans Girty, 1911

Pl. 1-8, figs. 11, 13

Metacoceras perelegans Girty, 1911, p. 147-148; 1915, p. 244-245, pl. 30, figs. 5, 6; Sturgeon, 1937, p. 358; 1946, p. 12, 25-26, pl. 6, figs. 3, 4; Unklesbay, 1962, p. 37-38, pl. 3, figs. 6, 7; Murphy, 1970, p. 198-199 (in part).

Metacoceras sp. #1 Sturgeon?, 1946, p. 27, pl. 6, figs. 6, 7.

Metacoceras sp. #2 Sturgeon?, 1946, p. 27-28, pl. 6, figs. 12-15.

Diagnosis.—Small to medium-sized *Metacoceras* having moderately narrow whorls bearing a slightly depressed midventral zone and dorsolateral and ventrolateral nodes connected by rather straight transverse ribs normal to conchal axis on intermediate growth stages.

Material.—Approximately two dozen specimens from the Columbiana, Lower Mercer, Vanport, and Washingtonville units are assigned to this species. All specimens are incomplete, but several are well preserved with respect to original shape. Only two have one or more whorls intact and the others have retained no more than half a whorl. The measurements and ratios in table 1-8 were determined on Girty's holotype (USNM 120696) and several of our hypotypes. Although there are some variations in the ratios, particularly in the W/D ratio, it is believed that these can be explained by variation among individuals, different stages in growth, and difficulties in obtaining precise measurements.

Description.—Conch small to medium sized, tarphyceraconic, subdiscoidal to subglobose, consisting of at least two whorls, gradually and regularly expanded in size; umbilicus moderately wide, deep, steep sided, gradate, and presumably perforate; whorl section depressed and subhexagonal in outline, having a moderately convex venter and a flattened to weakly depressed median zone, nearly straight to faintly convex flanks converging slightly ventrad, umbilical walls also nearly flat to slightly convex, and dorsal surface impressed; angles at ventrolateral and dorsolateral shoulders and at umbilical seams obtuse, the latter two more widely obtuse; all three angular on exterior, first two rounded on internal mold; whorls in early stages of growth also rounded. Test thin, less than 0.5 mm thick on venter, flanks, and umbilical walls, thicker in shoulders and nodes, marked by transverse lirae separated by striae or rounded troughs, lirae of unequal strengths on certain specimens (OSU 19544 and 19545); transverse markings extending far apicad on venter to form a deep, widely flaring, U-shaped sinus, nearly straight across flanks and deflected slightly apicad on umbilical walls, faint longitudinal lines visible on venter of a few specimens (such as OSU 19545); surfaces of earliest preserved growth stages ". . . marked by fine, even, transverse, rounded striae, separated by narrow sharp lirae" (Girty, 1915, p. 244); at approximately one-half whorl stage of growth, surface marked by transverse plications terminated in rounded nodes on ventrolateral and umbilical shoulders; plications becoming less strongly developed orad and finally disappearing; ventrolateral nodes larger than those on umbilical shoulders and elongated in direction of coiling before disappearance of plications. Internal mold smooth except for a small, long, median ventral ridge, two low, broad, rounded ridges bordering midventral depressed zone, subdued knobs and ridges under ventrolateral nodes, transverse lateral plications, and sutures. Sutures slightly sinuous, approximately 3 mm apart on venter and forming definite ventral and lateral lobes separated by less pronounced ventrolateral saddles; sutures in nearly straight

TABLE 1-8.—*Conch measurements and ratios of* Metacoceras perelegans

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
USNM 120696 (holotype)	30	16	12	18	0.60	0.67	0.53
OSU 18719 (hypotype)	35	17.2	12.5	18.5	0.53	0.67	0.50
OSU 19540 (hypotype)			6.7	10.3		0.65	
OSU 19544 (hypotype)			7.5	12		0.63	
OSU 19545 (hypotype)	26	13.3	10.2	14.2	0.55	0.72	0.55
?OSU 18724[1] (hypotype)			9.6	14.7		0.65	
?OSU 18724[1] (hypotype)			12.9	18		0.71	

[1] More than one specimen with same catalog number.

course across dorsolateral zone, having an additional saddle at umbilical seam and a strong dorsal lobe; septa nearly transverse to axis of whorl, dorsal edge a little farther orad, only moderately convex apicad, a little more so dorsoventrally than laterally; siphuncle slightly ventrad in position, of small diameter (approximately 0.6 mm at septum), presumably orthochoanitic; septal necks short and straight.

Remarks.—Pennsylvanian tainoceratid specimens that have transverse lateral ridges and dorsolateral and ventrolateral nodes have been referred to *Huanghoceras collinum* Young, 1942; *H. obliquicostatum* Young, 1942; *H. percostatum* Young, 1942; *Metacoceras angulatum* Sayre, 1930; *M. biseriatum* Miller & Owen, 1934; *M. decoratus* (Cox), 1858; *M. jacksonense* Miller, Lane & Unklesbay, 1947; *M. latum* Sturgeon, Windle, Mapes & Hoare, 1982; *M. mutabile* Miller & Owen, 1934; *M. mutabile* Miller, Lane & Unklesbay, 1947 (now named *M. simile* Sturgeon, Windle, Mapes & Hoare, 1982); and *M. perelegans* Girty, 1911. We have had opportunity to study type or valid specimens of these species, except *M. decoratus*. We believe that our specimens are conspecific with *M. perelegans*, as they correspond very closely with the holotype of that species in respect to dimensions of conch, umbilicus, and whorl and to ratios, with some allowance for variation within a species. The W/D ratios of two of our specimens (OSU 18719 and 19545) do indicate a more subdiscoidal conch than the holotype. In 1949, Miller and Youngquist placed in the genus *Foordiceras* a number of noded Permian species that have transverse lateral ribs. We have not made serious taxonomic consideration of these species.

Young (1942) placed his three species in *Huanghoceras*. We have briefly compared them in the discussion of *Metacoceras clinocostatum*. *Metacoceras angulatum* and *M. mutabile* have H/W ratios mostly above 0.80, indicating a more equidimensional whorl section than for *M. perelegans*. *Metacoceras biseriatum* is larger and has a wider and less rapidly expanding whorl section, a more circular coil, and nodes farther apart than for *M. perelegans*. Conspicuous longitudinal lines occur along the venter of *M. biseriatum*. *Metacoceras jacksonense* differs from *M. perelegans* in having a much larger conch and larger rounded ventrolateral nodes, longitudinally elongate nodes almost forming a carina on the umbilical shoulder, and an umbilical wall sloping inward at about 45°. *Metacoceras latum* has a much wider whorl section.

Comparison with *M. decoratus* is uncertain, as Cox's illustrations are drawings, and his type, which still exists, is unfortunately unavailable. Through the courtesy of Mackenzie Gordon and Lloyd Henbest, we have had opportunity to study two modern photographs of Cox's holotype. Dimensions of the holotype, listed by Cox, include conch diameter of 1.35 inches (34.3 mm), whorl height of 0.54 inch (13.7 mm), and whorl width of 0.81 inch (20.6 mm). W/D and H/W ratios are 0.60 and 0.66, respectively. These measurements and ratios compare very closely with similar measurements and ratios for the holotype of *M. perelegans*. One distinctive feature is the inclination of the lateral ribs, which on specimens of *M. perelegans* are nearly transverse, and on those of *M. decoratus* are inclined orad and ventrad. If it eventually can be demonstrated that Cox's and Girty's specimens are conspecific, Cox's specific name, *M. decoratus*, has priority. Without an opportunity to examine Cox's type, we are, however, tentatively considering it as a separate species.

Occurrence.—25 specimens total, several doubtful; Columbiana unit: 3 specimens each from locs. Cp-3, Mg-2, and Mg-7, 2 specimens from loc. Ss-5, 1 specimen each from locs. Cs-3 and Cs-8; Lower Mercer unit: 1 specimen from loc. LIho-1; Putnam Hill unit: 4 specimens from loc. Ms-3, 2 specimens from Mc-2; Vanport unit: 2 specimens from loc. Mp-1, 1 specimen each from locs. Vel-24 and Vs-3; Washingtonville unit: 1 specimen from loc. Ty-5.

Repository.—Holotype, USNM 120696; hypotypes OSU 18719, 18722 to 18724, 19539, 19540, 19544 to 19546, 30615.

Metacoceras tricarinatum tricarinatum Sturgeon, 1946

Pl. 1-8, fig. 15; pl. 1-9, figs. 2, 6, 11

Metacoceras tricarinatum Sturgeon, 1937, p. 358; 1946, p. 12, 24-25, pl. 5, figs. 5, 6.

Metacoceras carinatum Unklesbay, 1962, p. 34-35 (in part), pl. 3, figs. 3, 4.

Metacoceras cornutum Unklesbay, 1962, p. 35-37 (in part), pl. 2, fig. 6.

Diagnosis.—Small *Metacoceras* having rather large ventrolateral nodes and six longitudinal carinae, one on each of the umbilical shoulders and two on each of the ventrolateral shoulders.

Material.—Originally only two fragmentary and partially mashed specimens (syntypes, OSU 18717) from the Putnam Hill unit were available, but subsequently additional partial and flattened specimens from the same unit and a well-preserved, undistorted, fairly complete silicified specimen (hypotype, OSU 28889) from the Vanport unit have been collected. Additional details and the following measurements determined on the silicified hypotype can be added to the original description: D = 23 mm, U = 7.4 mm, H = 10 mm, W = 14 mm, W/D = 0.61, H/W = 0.71, U/D = 0.32.

Description.—Conch small, tarphyceraconic, regularly and gradually expanding except for rapid expansion of initial growth stage, subdiscoidal to subglobose; umbilicus moderately wide, deep, steep walled, and perforate; perforation large and half-moon shaped; whorl cross section moderately depressed, maximum width between ventrolateral shoulders, irregularly hexagonal to subrectangular in outline; venter moderately convex with flattened median zone; flanks flattened except for transverse ridges opposite ventrolateral nodes and a concave zone below carinae on umbilical shoulder; umbilical walls flattened, very slightly sigmoidal and steeply sloping inward; dorsum weakly impressed less than width of previous whorl, impression estimated to be less than 1 mm deep at an impressed width of approximately 3.5 mm and width of previous whorl of about 5.5 mm; ventrolateral and umbilical shoulders and umbilical seam obtusely angular; ventrolateral shoulder ornamented with a single row of nodes and two carinae; nodes rather large (1.5 mm to 2 mm high), spaced approximately 4 mm apart, bluntly rounded, extending longitudinally and transversely onto flanks; one carina (the stronger) on venter just below nodes, the other extending through nodes, stronger across nodes and diminishing in size orad; umbilical shoulder also elevated into a strong carina. Test rather thin, normally less than 1 mm thick, thickened in angulations, carinae, and nodes so that the latter two only reflect weakly or not at all on internal mold; surface of test additionally ornamented by distinct growth lirae, very strong on oldest half-whorl, on carinae of umbilical shoulders, and across ventrolateral nodes, weakest on umbilical walls; nearly transverse on flanks and umbilical walls, slightly extended orad between ventrolateral carinae, and outlining a deep broad sinus on venter; oldest whorl rounded, rapidly expanded, and marked only by strong growth lirae on oldest 3.5 mm of conch growth; nodes and ventrolateral lirae through them appear abruptly at one-half whorl of growth, dorsolateral angulation and carina not developed until almost one whorl of growth completed. Internal conch features still mostly unknown except for outline of a possible septum and uncertain suture and siphuncle on silicified hypotype.

Remarks.—This distinctive subspecies apparently is similar to and possibly closely related to *Metacoceras carinatum* Girty and *M. t. parvinodosum* Sturgeon. It differs from Girty's species in the possession of the two ventrolateral longitudinal carinae and from Sturgeon's subspecies in having larger ventrolateral nodes. The close similarity between *M. tricarinatum tricarinatum* and *M. t. parvinodosum* and their stratigraphic co-occurrence suggest the possibility of sexually dimorphic forms in the same species, but, because they are morphologically recognizable, we are considering them as subspecies. The silicified specimen (OSU 28889) from the Vanport unit near McArthur, Ohio, is one of the best preserved specimens for surface details in our entire collection of cephalopods. We believe after examination that the specimens of *M. carinatum* Girty and *M. cornutum* Girty figured in Unklesbay (1962, pl. 3, figs. 3, 4 and pl. 2, fig. 6, respectively) and cited in the synonymy above are representatives of *M. tricarinatum tricarinatum*. Sturgeon's use in 1937 of this name and that of *M. t. parvanodosum* has no valid standing.

Occurrence.—9 specimens total; Putnam Hill unit: 3 specimens from loc. Vel-15, 2 specimens each from locs. Mg-4 and Ms-3, 1 specimen from loc. Mc-3; Vanport unit: 1 specimen from loc. Vel-24.

Repository.—Syntypes OSU 18717; hypotypes, OSU 28889, OU F 301, 304, 308, 399.

Metacoceras tricarinatum parvinodosum Sturgeon, 1946
Pl. 1-9, figs. 3, 4, 10, 12

Metacoceras tricarinatum parvanodosum Sturgeon, 1937, p. 358.
Metacoceras tricarinatum parvinodosum Sturgeon, 1946, p. 12, 25, pl. 5, figs. 3, 4.
Foordiceras bellatulum Hansman, 1958, p. 201, 205-206.

Diagnosis.—Similar to *Metacoceras tricarinatum tricarinatum* Sturgeon but differing in possession of more numerous, more closely spaced, and smaller ventrolateral nodes.

Material.—In addition to the four original specimens available at the time this subspecies was named, seven more specimens have been collected. Normal preservation, as for the syntypes (OSU 18718), is one side of a partial whorl, except for one hypotype (OSU 28890), which is approximately one-third of an entire whorl slightly mashed on the left side of the venter. Another hypotype (OSU 28891) has a test of white aragonite (?); one specimen is much covered with fine crystals of pyrite. Another is a doubtful internal mold. The following few dimensions and ratios were determined on one of the hypotypes near its apicad end: D = 15 mm (est.), H = 4.1 mm, W = 5.6 mm, W/D = 0.37, H/W = 0.73.

Description.—Conch small, tarphyceraconic, regularly and gradually expanded; umbilicus wide, deep, and presumably perforate; whorl section moderately depressed; venter somewhat convex, apparently without median flattened zone; flanks flattened except for transverse ridges opposite ventrolateral nodes and a concave zone below carina on umbilical shoulder; umbilical walls definitely convex, dorsum very narrowly and weakly impressed; dorsolateral and ventrolateral shoulders obtusely rounded on internal mold, angular to subangular exteriorly; indistinct umbilical seam obtuse. Test thin to very thin, less than 1 mm thick except possibly in ventrolateral nodes, marked externally by numerous fine and fairly uniform growth lirae outlining a deep, rounded, V-shaped hyponomic sinus and following a nearly transverse course from innermost of two ventrolateral carinae across flanks and umbilical walls; test on each umbilical shoulder raised into a longitudinal carina and along ventrolateral shoulders into two longitudinal carinae (1 to 2 mm apart), the stronger one lying on venter and the other connecting small, bluntly rounded ventrolateral nodes (less than 1 mm high and 1.5 to 3 mm apart); bases of nodes also extended transversely, more onto flanks than onto venter; a doubtful internal mold has subdued replicas of ventrolateral nodes and longitudinal carinae. Septa spaced 1.2 to 1.8 mm apart on doubtful steinkern, one septum and a single suture well exposed on apicad end of specimen OSU 28890; septum nearly transverse, extended slightly orad dorsally, moderately and evenly convex apicad; suture having broad, shallow, rounded ventral and lateral lobes and a very slightly rounded lobe across umbilical and dorsal walls, a small, rounded ventrolateral saddle, an indistinct, rounded dorsolateral saddle, and a weak annular lobe at dorsal impression; siphuncle small (approximately 0.5 mm in diameter at septum), ventrad (1.1 mm from venter and 2.2 mm from dorsum).

Remarks.—*Metacoceras tricarinatum parvinodosum* differs noticeably from *M. t. tricarinatum* in being more discoidal and in the possession of smaller, more numerous, and more closely spaced ventrolateral nodes and seemingly wider spacing of the two ventrolateral carinae. It has already been noted that all specimens referred to these two forms may be variants of a single species—possibly sexual dimorphs. Because they are easily recognized, they are considered to be subspecies, even though they do occur in the same stratigraphic units. We do not agree with Hansman (1958, p. 201, 205-206), who tentatively placed this subspecies in the synonymy of *Parametacoceras bellatulum* Miller & Owen, which in turn he placed in the genus *Foordiceras* Hyatt. We have observed the type specimens of *P. bellatulum*, and they do not closely resemble our Ohio specimens of *M. t. parvinodosum*.

Occurrence.—11 specimens total; Putnam Hill unit: 5 specimens from loc. Ms-3, 4 specimens from loc. Mg-4, 1 specimen each from locs. Mc-1 and Td-4.

Repository.—Syntypes, OSU 18718; hypotypes, OSU 28890, 28891.

Metacoceras sp. #1
Pl. 1-9, figs. 9, 14-16

Diagnosis.—Medium-sized *Metacoceras* having subquadrate whorl section, numerous (estimated 25) ventrolateral nodes, and well-developed reticulate ornament on the venter.

Material.—We have four definite specimens (OSU 28955, 28956, 29245, and 29246). Three consist of approximately one-fourth of a mostly shell-bearing whorl, and the fourth of a mashed and partially embedded whorl; all are from the Brush Creek unit. A questionable distorted specimen (OSU 28957) of two-and-a-half whorls, embedded on the left side in matrix, is from the Putnam Hill unit. This specimen must have had a conch diameter of more than 60 mm. The whorl dimensions and ratios in table 1-9 were determined on two of the Brush Creek specimens.

TABLE 1-9.—*Conch measurements and H/W ratios of* Metacoceras *sp. #1*

Specimen	H (mm)	W (mm)	H/W
OSU 28955	20.7	26	0.80
OSU 28956	23	30	0.77

Description.—Conch medium sized, tarphyceraconic, subdiscoidal; umbilicus wide and steep walled; whorl section subquadrate to subpentagonal in outline, maximum width at or just below umbilical shoulders; venter convex but not strongly arched, with flattened or concave central band and a little wider than margins toward ventrolateral shoulders; flanks flattened, especially on internal mold, externally slightly sigmoidal with weak concavity above ventrolateral shoulders, particularly opposite nodes, and a similar convexity below umbilical shoulders; umbilical walls flattened but broadly concave between elevations of shell along umbilical seams and shoulders; dorsum slightly wider than umbilical wall, depressed approximately 1.5 mm by previous whorl at a width of 10 mm; corners at shoulders and umbilical seams subangular on exterior and rounded on internal mold, shoulders slightly obtuse and seams widely obtuse. Thinner portions of test less than 1 mm thick, thicker in shoulders, seams, and nodes; surface ornament of numerous fine striae separated by wider flat-topped bands forming a broadly rounded, shallow to moderately deep ventral sinus, a shallow sigmoidal pattern on flanks, orad convexity above ventrolateral shoulders, and nearly straight course to weakly orad convexity across umbilical walls; numerous longitudinal lines similar to but slightly weaker than growth lines on venter, especially well developed on middle portion, forming a reticulate pattern; faint longitudinal lines also visible on flanks of larger Brush Creek specimen (OSU 28956); ventrolateral shoulders having numerous (25+) unpaired, rather small nodes spaced 6 to 8 mm apart, generally rounded but slightly elongated lengthwise along the shoulder and upward onto flanks. Septa nearly transverse to whorl axis and rather strongly convex apicad, being evenly convex across and more strongly convex toward dorsum; sutures sinuous, having a moderately deep, evenly rounded ventral lobe, rounded asymmetrical lateral lobes, and rounded symmetrical dorsal lobe, nearly straight courses across umbilical walls, a well-developed, narrowly rounded saddle at each ventrolateral shoulder, and faint rounded saddles at umbilical shoulders and seams; siphuncle ventrad (about 8 mm above venter and 12 mm below dorsum); septal necks circular in outline (approximately 1.5 mm in diameter); connecting rings not observed.

Remarks.—The Brush Creek specimens are characterized by medium size, high and narrow whorl section, ventral reticulate surface ornament, and numerous ventrolateral nodes. They are most similar to *Metacoceras mcchesneyi* Murphy and to *Metacoceras* cf. *M. mcchesneyi* described herein. Our specimens differ in having more and smaller ventrolateral nodes per whorl, a higher H/W ratio (0.77 to 0.80 vs. 0.69), and a conspicuous reticulate surface pattern. Murphy (1970, p. 200) did report, however, that "Well preserved specimens [of *M. mcchesneyi*] also reveal faint longitudinal striae, most frequently noted on the dorsal half of the lateral walls and the mid-portion of the venter." Our specimens also differ from *Metacoceras* cf. *M. mcchesneyi* in having a higher H/W ratio and a deeper, widely flaring ventral lobe. It is possible that our specimens are variants or a subspecies of *M. mcchesneyi*, but until more complete specimens are available no definite decision can be made. Incomplete and poor preservation of the Putnam Hill specimen (OSU 28957) makes its taxonomic position even less certain.

Occurrence.—6 specimens total; Brush Creek unit: 2 specimens each from locs. Ale-35 and MEco-1, 1 specimen from loc. Cma-3; Putnam Hill unit: 1 specimen from loc. Ty-3.

Repository.—OSU 28955 to 28957, 29245, 29246.

Metacoceras sp. #2
Pl. 1-8, fig. 14; pl. 1-9, figs. 1, 7

Diagnosis.—Medium-sized to large *Metacoceras* having a wide umbilicus, rounded umbilical shoulders, and large, rounded, moderately spaced ventrolateral nodes.

Material.—We have six similar fragmentary specimens from the Lower Mercer unit that are different from our other specimens of *Metacoceras*. There are also three fragments in a mixed collection of *Metacoceras* from the Putnam Hill unit and a single specimen from the Brush Creek unit that appear to be similar to the Lower Mercer specimens. Most are only part of a whorl or an external mold of a whorl portion, and one of the Putnam Hill specimens might even be a piece of an immature temnocheilid. Our largest and best specimen (OSU 28959, pl. 1-9, fig. 7), which is the basis of our description, consists of approximately one-third whorl showing portions of the flanks, venter, ventrolateral shoulder, and umbilical shoulder and wall. It is estimated to have had a conch diameter of at least 75 mm and a wide umbilical diameter.

Description.—Conch medium sized to large, apparently tarphyceraconic and subdiscoidal; umbilicus wide; some details of whorl uncertain because of mashing; flanks flattened but mashed inward and venter narrowed and pushed outward; umbilical walls apparently slightly convex; cross section possibly equidimensional, estimated H/W ratio of 0.85 to 0.90; ventrolateral and umbilical shoulders rounded. Test variable in thickness, from less than 1 mm to more than 1 mm thick; surface ornament unknown except on a smaller specimen, where traces of fine growth lirae indicate a deep ventral sinus; ventrolateral shoulders having paired large, rounded, bluntly terminated nodes (estimated 20 or fewer per whorl). Details of septa, siphuncle, and sutures not observed.

Remarks.—As far as can be observed, the distinctive features of these specimens are their rather large, moderately spaced, bluntly rounded ventrolateral nodes and rounded ventrolateral and umbilical shoulders. The discrete rounded nodes and the rounded umbilical shoulders suggest *Metacoceras sinuosum* Girty from the Wewoka Formation of Oklahoma. Our specimens, except one Putnam Hill individual, seem to have shorter nodes than Girty's species. We are not certain that all of our specimens do represent a single species. One specimen (OSU 24599), from the Putnam Hill unit near Carbon Hill, may be a fragment of a temnocheilid. Another individual (OSU 28959) somewhat resembles *Mahoningoceras pottsvillense* (Morningstar). The Lower Mercer specimens (OSU 28960, 29320) from an abandoned cannel coal mine on Flint Ridge (loc. LIho-1) tend to have their nodes extended across the flanks. Until more complete and better material is available, we are retaining them together under the present taxon.

Occurrence.—10 specimens total; Brush Creek unit: 1 specimen from loc. Ad-32; Lower Mercer unit: 5 specimens from loc. LIho-1, 1 specimen from loc. Vel-26; Putnam Hill unit: 3 specimens from loc. Hw-16.

Repository.—OSU 24599, 28959, 28960, 29137, 29320.

Metacoceras sp. #3
Pl. 1-9, figs. 5, 8, 13

Diagnosis.—Small to medium-sized *Metacoceras* having a slowly expanded and relatively narrow whorl, pronounced midventral depressed zone, and carinate umbilical shoulders.

Material.—The only specimen is a fragment of a medium-sized individual consisting of approximately one-third whorl of a mostly exfoliated living chamber terminated at the adapical end by a single septum. Length along the preserved venter is almost 30 mm, and estimated conch diameter is at least 30 mm if the specimen is mature and larger if it is immature. Whorl height ranges from 8.5 to 8.7 mm, whorl width ranges from 10 to 11.8 mm, and H/W ratios range from 0.75 near the adoral end to 0.85 at the adapical end.

Description.—Conch small to medium sized, tarphyceraconic, subdiscoidal; umbilicus steep walled; whorl only moderately depressed, maximum width just above ventrolateral shoulder; venter biconvex with a broad median depressed zone bordered on each side by a broadly rounded but narrower tumid (protuberant) band or ridge expanded laterally into each ventrolateral node; flanks flattened except for elevated area around each of the ventrolateral nodes and a concavity between nodes, slightly convergent dorsad; umbilical walls steep, moderately and evenly convex; dorsum impressed deeper than height of convexity of umbilical surfaces and slightly wider than those surfaces; obtuse angles between surfaces at ventrolateral and umbilical shoulders and at umbilical seams, largest angle at the umbilical seams and smallest at ventrolateral shoulders. Test apparently thin (less than 1 mm thick) and almost completely exfoliated, remnants preserved on flanks, nodes, and umbilical shoulders; the latter apparently carinate but details not certainly preserved; ventrolateral nodes rounded, rather widely spaced (5 to 6 mm apart, estimated 12 per whorl), located on lower part of flanks but grading smoothly into ventral surface. Septum nearly transverse to whorl axis except for an orad deflection dorsally, moderately and evenly convex apicad; suture typical for genus, rather shallow and broadly rounded ventral, lateral, and dorsal lobes, dorsal lobe being much narrower and having more distinct but narrower saddles at ventrolateral shoulders and umbilical seams, a faint saddle at umbilical shoulders, and a nearly straight path across umbilical walls; no trace of siphuncle recognized.

Remarks.—This specimen can be readily recognized by its small to medium size, very gradual whorl expansion developing a rather narrow whorl having subparallel flanks in ventral view, a wide, rounded, distinct, depressed midventral zone, rather widely spaced ventrolateral nodes, and questionable carinate umbilical shoulders. The carinae may actually be a result of partial preservation of the test, but, because each shoulder is carinate, we suspect that the original outer surface must have been carinate. Although *Metacoceras carinatum* Girty has carinate umbilical shoulders, it differs in having a more depressed whorl and in lacking a depressed midventer. In fact, our specimen does not seem to represent any known species of *Metacoceras*; its incompleteness prevents full and adequate description and designation as a new species.

Occurrence.—1 specimen; Vanport unit: loc. Vel-19.

Repository.—OSU 28919.

Metacoceras spp.

Diagnosis.—Variable fragmentary unidentified specimens of *Metacoceras*.

Material.—We have quite a number of fragmentary specimens of *Metacoceras* that are of uncertain specific identity because of the nature of their preservation. We are citing one of these specimens (OSU 28958) because it is the only known cephalopod from the Dorr Run shale. It consists of a mere fragment of an internal mold showing the presence of three relatively large, distinct nodes.

Remarks.—The limited preservation of OSU 28958 prevents determining its specific identity or comparing it with other species.

Occurrence.—1 cited specimen; Dorr Run unit: loc. Ay-11.

Repository.—OSU 28958; numerous unidentified and unnumbered OU specimens.

Genus *Parametacoceras* Miller & Owen, 1934

Type species: *Parametacoceras bellatulum*
Miller & Owen, 1934; OD

Parametacoceras Miller & Owen, 1934, p. 232-233; Kummel, 1953, p. 4, 24; 1964, p. K414, fig. 297, 1a-c.
Foordiceras Miller & Youngquist, 1949, p. 96-97.

Diagnosis.—Tarphyceracones that differ noticeably from *Metacoceras* in that the ventrolateral shoulders lack conspicuous nodes and flanks lack strong transverse ribs.

Description.—See following description of *Parametacoceras bellatulum*.

Remarks.—Miller and Youngquist (1949, p. 96-97) and Hansman (1958, p. 201) placed this genus in synonymy of Hyatt's genus *Foordiceras*, but as early as 1953 Kummel (p. 24) restored *Parametacoceras* to valid generic status and in 1964 (p. K414) included it in part K of the Treatise on Invertebrate Paleontology. Because of differences in size of the conch and of umbilical perforation, in tightness of coiling, in nodes, and in geologic range, we prefer to recognize *Parametacoceras* as a distinct genus. This genus has been reported in Pennsylvanian strata of Kansas, Kentucky, Missouri, New Mexico and questionably Ohio, and in the Upper Carboniferous of the central part of the former Soviet Union.

Geologic range.—Pennsylvanian.

Parametacoceras bellatulum Miller & Owen, 1934
Pl. 1-10, figs. 1-5, 7, 8

Parametacoceras bellatulum Miller & Owen, 1934, p. 233-235, pl. 15, figs. 1-5; Hoare, 1961, p. 131, pl. 17, figs. 2, 3.
Foordiceras bellatulum Miller & Youngquist, 1949, p. 96; Hansman, 1958, p. 201-206, pl. 21, figs. 8-11.

Diagnosis.—Metacoceras-like forms possessing inconspicuous lateral transverse ribs bearing small nodes ventrally which disappear toward aperture of ultimate whorl.

Material.—The holotype and 21 other specimens, all from Missouri, are available. The holotype is a large and presumably mature specimen consisting of approximately two-and-one-third whorls. Dimensions and ratios of the holotype and several selected paratypes are listed in table 1-10. These figures indicate D (max.) = 32 mm, average W/D ratio = 0.53, H/W ratio = 0.71, and U/D ratio = 0.44. Several measurements and ratios vary considerably from the average; these may be reflect extremes among individuals and size variations. The body chamber of a longitudinally sectioned paratype (SUI 13412, pl. 1-10, fig. 5) is approximately one-half whorl in length.

Description.—Conch small to medium sized, tarphyceraconic, intermediate between subdiscoidal and subglobose, rapidly expanded; umbilicus moderately wide to wide and perforate; perforation raindrop shaped; mature whorl depressed, subrectangular, venter wide and flat to slightly concave; flanks and umbilical walls flattened but definitely convex and dorsum weakly impressed; ventrolateral shoulders obtuse and rounded; umbilical shoulders also obtuse and narrowly rounded, almost angular and nearly carinate; immature whorls also depressed, rounded subelliptical in outline, extended laterally into a bluntly pointed, noded ridge just above ventrolateral shoulders and exposed at or near contact between whorls; flanks and umbilical walls not distinctly separated on older part of first whorl, umbilical shoulders recognizable toward end of first whorl. Test rather thin, less than 0.5 mm thick, thicker in umbilical shoulders; initial whorl marked by numerous, strong, equal-sized growth lirae and striae, strength of these markings diminishing with increase in conchal size, striae becoming shallower and lirae wider; on mature whorls growth lines tracing a broadly rounded, moderately deep, U-shaped ventral sinus, rather narrowly rounded salient across ventrolateral shoulders, a nearly transverse but slightly sigmoidal course across flanks, and a weakly convex orad path across umbilical walls; on largest specimens, clearly discernible longitudinal lirae on venter and ventral part of flanks, most conspicuous along middle two-thirds of venter; ventrolateral angulation visible on some specimens at second half of first whorl; small rounded nodes above shoulders on low, rounded lateral plications separated by wider rounded troughs; both nodes and plications slightly sigmoidal and disappearing short of aperture on largest specimens. Internal molds marked by sutures and subdued replicas of lateral plications and nodes; earliest suture pattern nearly transverse and only slightly sinuous, mature sutures having shallow and rounded ventral, lateral, and dorsal lobes and more narrowly rounded ventrolateral and dorsolateral saddles; dorsal lobe having large annular lobe; septa spaced approximately two-fifths of whorl width along venter, moderately convex apicad, greater convexity between center and venter, and ventral edge extending farthest orad; siphuncle small (ranging from 0.5 to 1 mm in diameter), ventrad, dorsal distance varying three to six times greater than ventral distance from siphuncle to body wall; suborthochoanitic, contracted through septa and expanded into cylindrical connecting rings in most camerae and into subellipsoidal connecting rings toward body chamber; septal necks estimated to extend apicad one-fifth of distance between adjacent septa, margins of septal necks on dorsal side definitely recurved and those on ventral side seemingly almost straight (possibly some difference due to distortion).

Remarks.—Only a few occurrences of representatives of *Parametacoceras* have been noted. Miller and Owen (1934) referred four species to the genus, including the type species, *Parametacoceras bellatulum*, from the Cherokee Formation

TABLE 1-10.—*Conch measurements and ratios of* Parametacoceras bellatulum

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
SUI 13408 (holotype)	31.4	13.2	14.7	20	0.64	0.74	0.42
SUI 6184[1] (paratype)	11	8.2	7	10.2	0.39	0.64	0.52
SUI 6184[1] (paratype)	32	12.7	11.6	16.2	0.51	0.72	0.40
SUI 6185[1] (paratype)	29.5	12	8.5	11.3	0.40	0.75	0.41
SUI 6185[1] (paratype)	29	13	12.9	16.6	0.57	0.77	0.44
SUI 6185[1] (paratype)	28.5	13.3	11.4	16.7	0.58	0.69	0.46
SUI 6185[1] (paratype)	28	12.3	8.4	11.3	0.40	0.74	0.43
SUI 13412 (paratype)	19.6	13	12.5	11.1	0.57	0.73	0.51
SUI 13413 (paratype)	28	10.8	11.7	16.7	0.60	0.70	0.39
SUI 13414 (paratype)	28.7	12	11.2	17.7	0.62	0.63	0.42

[1] More than one specimen with same catalog number.

of the Midcontinent region, *Endolobus schucherti* Miller from the Pennsylvanian of New Mexico, *Nautilus nikitini* Tzwetaev from the Upper Carboniferous of Russia, and questionably *Temnocheilus crassus* Hyatt also from the Cherokee Formation of Kansas. In 1946, Sturgeon (p. 28-29) identified two doubtful specimens from the Allegheny Group of Ohio (see following description of *Parametacoceras* cf. *P. bellatulum*). Miller and Owen reported the septal necks to be about one-third the length of the connecting rings. We, however, observed on a sectioned paratype (SUI 13412, pl. 1-10, fig. 5) that the septal necks are much shorter than one-third of the length of the connecting rings and estimated them to be about one-fifth of the cameral length.

Occurrence.—22 specimens total; Cherokee Formation: 12 specimens from loc. MO:Hbo-1, 7 specimens from loc. MO:Hbo-3, 1 specimen each from locs. MO:Hbo-2, MO:Hbo-4, and MO:Ld-1.

Repository.—Holotype, SUI 13408; paratypes, SUI 6184, 6185, 13409, 13412 to 13414.

Parametacoceras cf. *P. bellatulum* Miller & Owen, 1934
Pl. 1-10, figs. 6, 9

Parametacoceras bellatulum Miller & Owen, 1934, p. 233-235, pl. 15, figs. 1-5.
Parametacoceras? sp. Sturgeon, 1937, p. 358; 1946, p. 12, 28-29, pl. 6, fig. 5.
Foordiceras bellatulum Miller & Youngquist, 1949, p. 96-97; Hansman, 1958, p. 201-206, pl. 21, figs. 8-11.

Diagnosis.—Resembling *Parametacoceras* but lacking longitudinal lines, nodes on the weak lateral plications, and faint carina on the umbilical shoulders.

Material.—The only known specimens are two largely testiferous incomplete individuals, one consisting of approximately one whorl and the other of a half whorl, both preserved only on one side. Measurements and ratios determined on the larger specimen are very approximate: D = 24 mm, U = 9.4 mm, W = 10 mm, H = 6 mm, W/D = 0.40, H/W = 0.60, U/D = 0.40.

Description.—Conch small, tarphyceraconic, discoidal to subdiscoidal; umbilicus moderate sized, steep walled, and presumably perforate; conch and whorls apparently regularly and gradually expanded orad; dorsoventral diameter of larger specimen increasing from 4 to 10 mm in a distance of one whorl; whorl section apparently subquadrangular to subhexagonal, flanks possibly distorted in later stages of growth but rounded in earlier stages; as preserved, largest growth stages gently convex ventrally, flattened laterally, weakly convex across umbilical walls, and depressed an undetermined amount dorsoventrally; ventrolateral and umbilical shoulders rather abruptly but obtusely rounded, the former seemingly broader but probably somewhat distorted. Test approximately 0.5 mm thick, ornamented by transverse fine lirae and striae delineating a deep, rounded, U-shaped ventral sinus and sigmoidal patterns on flanks and umbilical walls; transverse lateral plications marked medially by an extra strong lira on apicad part of preserved whorls, plications more elongate but more obscure and unnoded following pattern of sigmoidal growth lines on orad portion of whorls. Exfoliated portion of larger specimen showing parts of four septa adjacent to living chamber, last three closer together, suggesting a mature specimen; sutures nearly transverse and slightly sinuous, having shallow, broad, rounded ventral and lateral lobes and narrowly rounded ventrolateral and dorsolateral saddles; dorsal sutures and siphuncle unknown.

Remarks.—Sturgeon (1946, p. 28-29) had previously studied these specimens and provisionally referred them to *Parametacoceras*. We have had the opportunity to examine Miller and Owen's types of *P. bellatulum* (type species of the genus) and are convinced that our specimens may well be variants of that species. Although our specimens lack the small nodes on the lateral plications, the fine longitudinal lirae, and the weak carina on the umbilical shoulder, two of Miller and Owen's paratypes (SUI 13412) show surface features similar to our specimens. It will be impossible to make positive identification and comparisons until more and better Ohio specimens are available. We do not follow Miller and Youngquist (1949, p. 96-97) and Hansman (1958, p. 201-206) in placing this species in the genus *Foordiceras* Hyatt.

Occurrence.—2 specimens; Putnam Hill unit: loc. Mg-4.

Repository.—OSU 18725.

Genus *Endolobus* Meek & Worthen, 1865

Type species: *Nautilus spectabilis* Meek & Worthen, 1860;
SD Meek and Worthen, 1866

Endolobus Meek & Worthen, 1865, p. 259; 1866, p. 307-308; Miller, Dunbar & Condra, 1933, p. 193-198, fig. 31A, B; Miller & Youngquist, 1949, p. 39-40; Kummel, 1964, p. K424-K425, fig. 305, 1a, b; Gordon, 1964, p. 133-134.
Temnocheilus Meek, 1876, p. 492; Hyatt, 1900, p. 524.

Diagnosis.—Large evolute nautilicones having a deep umbilicus and subelliptical whorls bearing a row of large lateral nodes on each side and prominent dorsal lobe with annular lobe.

Description.—Conch weakly nautiliconic, subdiscoidal to discoidal; whorl section depressed, subelliptical in outline, broadly rounded ventrally, narrowly rounded laterally, slightly impressed dorsally (figs. 1-7B, N); umbilicus wide, deep, and apparently perforate; row of low rounded nodes on flanks, diminishing in size and disappearing toward aperture on mature whorls. Test thick, quite smooth on adult shell, marked by growth lines indicating a rather deep, rounded, tongue-shaped hyponomic sinus, elongate lirae on young conchs and persisting on adult shells of some species. Septa approximately normal to conchal axis, orad concavity of septa rather shallow; sutures transverse, slightly sinuous; external sutures forming either a ventral saddle or lobe, the latter bordered by lateral saddles; internal suture having a prominent dorsal lobe with a narrow annular lobe; siphuncle small, subcentral in position, orthochoanitic.

Remarks.—Meek and Worthen (1865) originally designated *Nautilus (Endolobus) peramplus* Meek & Worthen as the type species of *Endolobus*. However, the following year they recognized that species as a synonym of *Nautilus spectabilis* Meek & Worthen, which then became the type species of the genus. The type species came from Chesterian rocks in Illinois. Gordon (1964, p. 133-134) listed 11 species of *Endolobus* from North America, two or possibly three of which are Pennsylvanian in age; only one is from the Permian System. To his list can be added another Pennsylvanian species, *Endolobus ortoni* (Whitfield), which he was hesitant to include but which we are confident is an *Endolobus*. *Endolobus* specimens occur throughout the Pennsylvanian of the United States, but they are most plentiful, although not abundant, in the lower part of the system. We believe that there are at least two species in available collections of Ohio specimens.

Some specimens have been referred to *Endolobus* or to *Temnocheilus* M'Coy, which has been amended and subdivided. *Temnocheilus* and related genera are characterized by elongate or rounded ventrolateral nodes, subelliptical or subtrapezoidal whorl sections, and longitudinal cuspate ornament in early stages of growth. Kummel (1964, p. K427) lists only elongate nodes and subtrapezoidal whorl section for *Temnocheilus*, but in practice some species assigned to that genus have rounded nodes and others, including the type species (*T. coronatus* M'Coy) have subelliptical mature whorl sections. Hence assignment of certain specimens to either genus has been a very subjective decision and generic designation of small, distorted, and fragmentary specimens cannot be done easily or with certainty. Other generic names that have been used or considered for one or more species include *Bisiphytes (Bisiphites)* de Montfort, *Nautilus* Linnaeus, and *Solenochilus* Meek & Worthen.

Geologic range.—Upper Mississippian-Lower Permian.

Endolobus ortoni (Whitfield), 1882
Pl. 1-11, fig. 1

Nautilus ortoni Whitfield, 1882, p. 231-232; 1891, p. 601-602, pl. 16, fig. 20; 1893, p. 486-487, pl. 12, fig. 20; Gordon, 1964, p. 134.
Endolobus (*Temnocheilus*?) *ortoni* Morningstar?, 1922, p. 270-271.
Gastrioceras fittsi? Gordon, 1964, p. 134, 260.
Endolobus ortoni Murphy, 1974, p. 740-742, pl. 1, figs. 1, 2.

Diagnosis.—Large, subdiscoidal tarphyceracones having broadly rounded venter; slightly obtuse, narrowly rounded umbilical shoulder with 18 nodes on adult whorl, steep sigmoidal umbilical wall; and nodes reduced in size almost to disappearance on outer one-third whorl.

Material.—Whitfield's holotype (AMNH 7426 G), from the Lower Mercer unit near Ellet (formerly called North Springfield) in Summit County, Ohio, is incomplete and weathered, does not reveal most internal features, and is not a very satisfactory specimen. It consists of the left side of a conch that retains about one-and-one-half whorls; its apical end and right side are concealed in matrix and appear not to be preserved. The umbilical seam is likewise covered on the exposed left side. Conch and whorl dimensions and ratios based upon the holotype are difficult to ascertain and several are only approximate estimations: D = 115 mm, U = 70 mm, H (approx.) = 35-40 mm, W (est.) = 55-60 mm, W/D (approx.) = 0.50, H/W (approx.) = 0.65, U/D = 0.61. Morningstar referred to this species a doubtful steinkern (OSU 15329) from the Lower Mercer unit along Blunt Run in Muskingum County.

Description.—Conch large, tarphyceraconic, subdiscoidal; depressed whorl broadly rounded ventrally, narrowly rounded over slightly obtuse umbilical shoulder, steeply sigmoidal on umbilical wall, convex and steep near shoulder, and concave and turned inward toward axis of coiling above umbilical seam, adjacent to which seam convexity again prevailing, presumably weakly impressed dorsally; umbilical shoulders nodose, nodes bluntly rounded, transversely elongate onto ventrolateral region of adult whorl, closely spaced (18 per whorl) and separated by rather narrowly rounded troughs; margins of nodes toward umbilicus abrupt, nodes becoming reduced and obsolete on last one-third whorl. Test thick (1 to 2 mm), thickest on umbilical shoulder and ventrolateral areas, apparently thinner on last one-third whorl orad; surface weathered and retaining no traces of surface ornament. Features of phragmocone not preserved or visible except on a small exfoliated area toward apical end; traces of two or three transverse straight sutures indistinctly visible.

Remarks.—The numerous blunt, rounded lateral nodes elongated onto the ventrolateral surface, the steep sigmoidal umbilical wall, and possibly the disappearance of the nodes on the orad one-third whorl are distinctive features of this species, although disappearance of the nodes is most likely a generic trait. Even though a number of salient features are unknown, *E. ortoni* seems to be distinct from other known Pennsylvanian species of *Endolobus*.

Morningstar's fragmental steinkern (OSU 15329) from the Lower Mercer unit can only be doubtfully identified, but as far as can be determined might well be a representative. Her statement that nodes are absent from a small portion near the end of the last volution is true, but is due to breakage, not to obsolescence, as that edge of the shoulder is missing. Her citation of an additional specimen from the Lower Mercer unit on Symmes Creek in Muskingum County cannot be checked, as the specimen cannot be located. Murphy's citation of a specimen (AMNH 28740), from the Columbiana unit appears to be a valid specimen from his photograph (1974, pl. 1, fig. 2). This specimen, unfortunately, is now almost completely disintegrated. Gordon's conjecture (1964, p. 134, 260) that this species is possibly a representative of the ammonoid *Gastrioceras fittsi* Miller & Owen is unfounded, as there are traces of nautiloid sutures on the holotype.

Occurrence.—3 specimens total; Columbiana unit: 1 specimen from loc. Mg-6; Lower Mercer unit: 1 specimen each from locs. MUmu-3 and SUsp-2.

Repository.—Holotype, AMNH 7426 G; hypotypes, AMNH 28740, OSU 15329 (doubtful).

Endolobus cf. *E. forbesianus* (McChesney), 1860
Pl. 1-11, fig. 2; pl. 1-12, fig. 2

Nautilus forbesianus McChesney, 1860, p. 63; 1865, pl. 3, figs. 4a, b; 1868, p. 50-51, pl. 3, figs. 4a, b; White, 1884, p. 165, pl. 36, figs. 3, 4; Herrick, 1887, p. 146, pl. 14, fig. 13.
Temnocheilus forbesianus Weller, 1898, p. 629.
Temnocheilus forbesianus Mark?, 1912, p. 270, 274, 279, 299; Morningstar?, 1922, p. 41, 46, 144, 271-272.
Endolobus forbesianus Shimer & Shrock, 1944, p. 547, pl. 223, figs. 17, 18.

Diagnosis.—Large *Endolobus* having 12 to 14 large, rounded nodes per mature whorl, nodes reduced on last one-third of that whorl.

Material.—Nine incomplete specimens are available: six from the Putnam Hill unit, two from the Columbiana unit, and one from the Lower Mercer unit. Seven are partially preserved on one side. The amount of preserved conch ranges from less than half a whorl to more than two whorls; approximate diameters range from 100 to 140 mm. The largest and most complete conch (OSU 28866) has the following approximate dimensions and ratios: D = 140 mm, U = 90 mm, H = 45 mm, W (est.) = 60 mm, W/D = 0.43, H/W = 0.75, U/D = 0.64.

Description.—Conch large, moderately expanded, tarphyceraconic, subdiscoidal; umbilicus wide; whorl section depressed, subelliptical in outline, with broadly rounded ventral and ventrolateral areas and obtusely rounded umbilical shoulders becoming more obtuse on last one-third whorl orad, bearing 12 to 14 rounded nodes per whorl, and becoming flattened on body whorl; nodes blunt, rounded but slightly elongate onto ventral surface and more abruptly terminated on umbilical wall but also bulging onto that wall; nodes separated by rounded concave spaces about same width as diameter of nodes, oldest preserved nodes elongate and intervening concave areas less definite, length possibly accentuated by mashing; nodes on last one-third whorl orad progressively smaller and lower, practically disappearing along with separating concave areas. Test variable in thickness, normally 1 to 5 mm thick, thickest in nodes along umbilical shoulders, thinnest in umbilical wall; external ornament not preserved. Internal mold mostly concealed, internal features not discernible.

Remarks.—Comparison between our specimens and McChesney's species must be based upon external features because our specimens do not preserve internal features. Our largest specimen (OSU 28866) is larger than the specimens illustrated by McChesney and by White. Our specimens are largely shell covered, theirs are almost entirely exfoliated; our largest specimen presumably has at least part of the body chamber, theirs do not retain any part of the body chamber. The smaller size and immature stage of their specimens account for the lack of a body chamber and probably for lack of reduction in size of nodes. The size, shape, and number of nodes are comparable, but their specimens appear to have a flatter venter and a more convex umbilical wall than ours. Although our specimens may not be conspecific with *Endolobus forbesianus*, they most nearly resemble that species among known American Pennsylvanian species of *Endolobus*. *Endolobus ortoni* (Whitfield) resembles our specimens in certain features, but has more numerous and smaller nodes per whorl. Mark's and Morningstar's citations of *Temnocheilus forbesianus* cannot be checked, as their specimens are no longer extant. Collinson (1955, p. 180) stated that: "*Nautilus forbesianus* McChesney . . . does not belong in the genus [*Endolobus*] because it possesses no dorsal lobe . . . ." Gordon (1964) followed Collinson in excluding McChesney's species from *Endolobus*. We are not inclined to place these specimens resembling *Endolobus* in another genus. Until another genus is available for them, we are retaining McChesney's species in *Endolobus* as a matter of convenience for description and comparison with our specimens.

Occurrence.—9 specimens total; Columbiana unit: 2 specimens from loc. Twa-1; Lower Mercer unit: 1 specimen from loc. Sb-1; Putnam Hill unit: 2 specimens from loc. Vel-15; 1 specimen each from locs. Hw-16, Ms-3, Twy-5, and Ty-3.

Repository.—Hypotypes, OSU 28866 to 28869.

Genus *Temnocheilus* M'Coy, 1844, revised by Sturgeon, Windle, Mapes & Hoare, 1982

Type species: *Nautilus* (*Temnocheilus*) *coronatus* M'Coy, 1844; SD Hyatt, 1884

Nautilus (*Temnocheilus*) *coronatus* M'Coy, 1844, p. 20-21, 255, pl. 4, fig. 15.

Temnocheilus Hyatt, 1884, p. 283; 1900, p. 524; 1913, p. 605; Foord, 1900, p. 49-51, pl. 18, figs. 1a-2b; Miller, Dunbar & Condra, 1933, p. 156-160 (in part), pl. 13, figs. 5, 6; Miller & Owen, 1934, p. 221-222, fig. 2B; Miller & Youngquist, 1949, p. 94; Kummel, 1953, p. 17-18 (in part), figs. 5, 6, 7m, table; 1964, p. K427, fig. 306, 1a, b; Turner, 1954, p. 317-320, pl. 21, fig. 14, pl. 22, figs. 12-14, pl. 25, figs. 4, 5; figs. 2, 3; Sturgeon, Windle, Mapes & Hoare, 1982, p. 1460-1462, figs. 3A, B, E.

Diagnosis.—Large, loosely coiled conchs having a wide, perforate umbilicus; in early growth stages longitudinal and cuspate ornament present, in more mature stages pronounced ventrolateral nodes present; whorl section subelliptical.

Description.—See description of *Temnocheilus coronatus* M'Coy.

Remarks.—The above diagnosis is based primarily on earlier descriptions by Miller, Dunbar, and Condra (1933, p. 159), Miller and Youngquist (1949, p. 94), and Kummel (1964, p. K427), but we are emphasizing the significance of the longitudinally ornamented initial growth stage of the conch and of the subelliptical section of mature whorls (figs. 7A, 7H). These features had been noted previously by Foord (1900, p. 50) in comparing *Temnocheilus coronatus* with *Nautilus tuberculatus* Sowerby; he noted the ". . . acutely elliptical form of the transverse section of the whorls . . . ." Turner (1954, p. 318, fig. 3) also noted that *T. coronatus* has more strongly inward sloping umbilical walls and more elliptical whorl sections than most Pennsylvanian and Permian species placed in the genus. He likewise observed longitudinal ornament on the inner whorl of hypotypes of *T. coronatus*. Because the description of *Temnocheilus coronatus* M'Coy is not readily available, we have summarized the salient features of that species on p. 49.

In addition to longitudinal ornament on the initial whorl of the type species of *Temnocheilus* M'Coy, we have observed similar ornament on two species of *Latitemnocheilus* and on the two known species of the related genus *Mahoningoceras* Murphy. We suspect that longitudinal ornament on the oldest portion of the conch is characteristic of all temnocheilids and that this ornament is seldom observed because it generally has been destroyed or concealed. It seems likely that temnocheilids are descended from ancestors with longitudinally lirate conchs, illustrated possibly by such Mississippian genera as *Chouteauoceras* Miller & Garner and *Discitoceras* Hyatt. If this inference is correct, it indicates that temnocheilids were not the ancestor of, or closely related to, *Metacoceras* as suggested by Miller, Dunbar, and Condra (1933, p. 160), Miller and Owen (1934, p. 221), and Miller and Youngquist (1949, p. 94). Our observations on many specimens of *Metacoceras* reveal only growth lirae on early growth stages of their conchs. Hence, temnocheilids certainly do not belong to the family Tainoceratidae. We are following Turner (1954, p. 316-317) in retaining them in the family Temnocheilidae, rather than placing them in the family Koninckioceratidae, as Kummel (1964, p. K427) has done.

Latitemnocheilus was undoubtedly derived from *Temnocheilus* as indicated by its subelliptical intermediate whorl outlines. Hence, immature specimens of *Latitemnocheilus* can be mistaken for *Temnocheilus*. *Mahoningoceras* appears to be an offshoot from the common ancestral stock of these three genera in which the mature whorl section became, or possibly remained, equidimensional. On the basis of mature whorl sections, longitudinal ornament on the initial part of conchs, and variation in ventrolateral nodes, we recognize the preceding three genera with confidence. The following North American species are recognized in these genera:

Temnocheilus M'Coy, 1844:
  T. annulonodosus Sturgeon, Windle, Mapes & Hoare, 1982;
  T. quinqueliratus Sturgeon, 1946;
  Temnocheilus sp. Miller & Owen, 1934.
Latitemnocheilus Sturgeon, Windle, Mapes & Hoare, 1982:
  Nautilus (*Temnocheilus*) *latus* Meek & Worthen, 1870 (type species);
  N. (*T.*) *winslowi* Meek & Worthen, 1870;
  Temnocheilus harneri Miller & Owen, 1934;
  T. johnsoni Miller, Dunbar & Condra, 1933;
  T. medioventralis Sturgeon, 1946;
  T. subrectangularis Miller, Dunbar & Condra, 1933;
  Temnocheilus spp.
Mahoningoceras Murphy, 1974:
  Metacoceras pottsvillensis Morningstar, 1922;
  Nautilus (*Gyroceras*?) *subquadrangularis* Whitfield, 1882 (type species);
  Temnocheilus searighti Unklesbay & Palmer, 1958 (synonym of *M. pottsvillense*).

Crude illustrations (pl. 1-16, figs. 2, 3) of the unrecognizable *Ammonites bellicosus* Morton, 1836 suggest that that species, if it ever can be validated, is a representative of the genus *Latitemnocheilus*. Turner (1954, p. 317) cited *Knightoceras* Miller & Owen, 1934 and *Subvestinautilus* Turner, 1954 as kindred genera, and we place them in the Temnocheilidae with some reservation. We are uncertain concerning his possible suggestion for *Foordiceras* Hyatt.

Geologic range.—Mississippian (Lower Carboniferous)-Permian.

Temnocheilus coronatus M'Coy, 1844

Nautilus (*Temnocheilus*) *coronatus* M'Coy, 1844, p. 20-21, 255, pl. 4, fig. 15.
Temnocheilus coronatus Foord, 1900, p. 49-51, pl. 18, figs. 1a-2b; Turner, 1954, p. 319-320, pl. 21, fig. 14, pl. 22, figs. 12-14, pl. 25, figs. 4, 5; figs. 2, 3; Sturgeon, Windle, Mapes & Hoare, 1982, p. 1462-1463, figs. 3A, B, 4A-C.

Diagnosis.—Subdiscoidal evolute conch having a perforate umbilicus; cross section of mature whorls depressed, subelliptical (fig. 1-7A); longitudinally ornamented in early growth stages.

Material.—We have not seen the holotype (NMI G-2), which is a somewhat distorted incomplete phragmocone of two- and-a-half whorls having a preserved diameter of 55 mm. The late J. S. Turner, of Leeds University, however, did observe the holotype and had it photographed for us. We have also used information from Turner's description (1954, p. 319-320) of two larger incomplete hypotypes (JW 1441, 1444), with respective diameters of 70 and 80 mm; these are reposited in the James Wright collection of the Royal Scottish Museum, Edinburgh, Scotland.

Description.—Conch tarphyceraconic; umbilicus perforate, original diameter of perforation in holotype estimated to have been 6 mm; initial whorl rounded, second whorl definitely depressed and ventrolaterally tuberculate, third whorl depressed and subelliptical in cross section with acutely rounded and tuberculate ventrolateral shoulder, faint growth lines indicating a strong hyponomic sinus; holotype and one hypotype (JW 1441), have exposed longitudinal ornament on earliest whorl; external suture on larger hypotype (JW 1444) described by Turner (1954, p. 320) as follows: ". . . consists of a very broad, flat-bottomed, ventral lobe, separated by a nearly symmetrical, subangular ventrolateral saddle from a shallower, evenly curved lateral lobe occupying the umbilical wall." Siphuncle reported to be subcentral and orthochoanitic.

Remarks.—A brief summary of significant morphological features follows: tarphyceraconic conch, perforate umbilicus, subelliptical mature whorl section with ventrolateral nodes, longitudinal ornament during early ontogeny.

Occurrence.—3 specimens total; Lower Carboniferous limestone: 1 specimen from loc. ICli-1; Middle Viséan limestone: 2 specimens from loc. Eim-1.

Repository.—Holotype, NMI G-2; hypotypes, RSM JW 1441, 1444.

Temnocheilus annulonodosus Sturgeon, Windle,
Mapes & Hoare, 1982
Pl. 1-13, figs. 1-5; pl. 1-14, fig. 1; pl. 1-21, fig. 7

Temnocheilus bellicosus Murphy, 1974 (*non* Morton, 1836), p. 742-746, pl. 1, figs. 3-5 pl. 2, figs. 1-4 (in part).
Temnocheilus annulonodosus Sturgeon, Windle, Mapes & Hoare, 1982, p. 1463-1465, pl. 1, fig. 1; pl. 2, fig. 8; pl. 3, fig. 1; table 2.

Diagnosis.—Medium-sized to large temnocheilid having gradually extended, evolute conch; discrete high, rounded ventrolateral nodes; and fine longitudinal lirae on the venter of outer whorls.

Material.—There are 45 incomplete specimens available. The most complete specimens include the holotype (OSU 28880), which consists of about three-fourths of a whorl, and two somewhat distorted and mashed specimens (OSU 28882 and 28888), each consisting of at least one whorl. Several of the less complete specimens have a white test of aragonite, are undistorted, and have excellent preservation of nodes and surface markings. The following dimensions were measured on the holotype (OSU 28880) and a paratype (OSU 19549): D (est.) = >100 mm, W/D (approx.) = 0.64, H/W (approx.) = 0.60 to 0.67.

Description.—Conch medium sized to large, tarphyceraconic, evolute, tending to become more loosely coiled at maturity; growth rate on conch gradual; mature whorl section subelliptical, venter convex; ventrolateral shoulder acutely angular, rounded, and sloping inward and dorsally across flanks and umbilical walls without distinct separation between those two surfaces; mature dorsal surface impressed approximately 2 mm deep and 15 mm wide at a conch diameter of 78 mm. Test approximately 1 mm thick, slightly thicker on largest specimens, thinner in flanks and umbilical walls, thicker in venter and ventrolateral areas, and much thicker in nodes; surface marked by numerous distinct growth lirae revealing a wide, shallow, rounded, V-shaped hyponomic sinus, passing nearly straight across internodal spaces and flanks and sharply rounded over nodes; venter on best preserved specimens and especially on a paratype (OSU 28881) having fine longitudinal lirae (estimated 10 and possibly 12 or more per whorl) less distinct than growth lines; high rounded nodes extending across flanks and forming a concavity between their bases and the midventer, possessing nearly vertical slopes orad and less steep slopes apicad, attaining maximum heights of 12 mm or more in a single, slightly offset row on each ventrolateral shoulder. Septa moderately and evenly convex apicad, except for small apicad bulge adjacent to annular lobe, nearly transverse to whorl axis, slightly extended orad dorsally; sutures slightly sinuous with broad, shallow to very shallow ventral, lateral, and dorsal lobes, the latter with a small annular lobe; lobes separated by much narrower saddles at ventrolateral shoulders and at umbilical seams; siphuncle slightly dorsad, almost 3 mm in diameter.

Remarks.—*Temnocheilus annulonodosus* is distinguished by its size, slow rate of expansion of its whorls, distinct high, rounded ventrolateral nodes, ventral longitudinal lirae, and slightly dorsad position of the siphuncle. *Temnocheilus quinqueliratus* Sturgeon is similar in size and nodes, but has more rapid expansion of the whorls and five longitudinal ridges on the internal mold. *Latitemnocheilus harneri* (Miller & Owen) and *L. winslowi* (Meek & Worthen) have distinct rounded nodes but are larger species that have subrectangular whorl cross sections; *L. winslowi* also has a much more rapid expansion of its whorls. *Latitemnocheilus subrectangularis* (Miller, Dunbar & Condra) has distinct longitudinal lirae and differs in having a definitely rectangular whorl section and confluent ventrolateral nodes. We have observed the specimens that Murphy (1974, pl. 1, figs. 3-5, pl. 2, figs. 1-4) illustrated and referred to *Temnocheilus bellicosus* (Morton), and we consider them to most likely represent *T. annulonodosus*. We do not believe, however, that his inclusion of *T. medioventralis* Sturgeon (now included in the genus *Latitemnocheilus*) should be included under the present species, as mentioned in the discussion of *L. medioventralis*.

Occurrence.—45 specimens total; Columbiana unit: 7 specimens from loc. Mg-6, 3 specimens from loc. Cuc-4, 1 specimen each from locs. Cp-1, Cs-7, Mg-10, Msp-1, and Msp-2; Putnam Hill unit: 11 specimens from loc. Hw-16, 4 specimens from loc. Ms-3, 2 specimens from loc. Tsc-3, 1 specimen from loc. Ty-3; Putnam Hill-Vanport units undifferentiated: 7 specimens from loc. Td-4; Vanport unit: 3 specimens from loc. MUho-3; Washingtonville unit: 1 specimen each from locs. CAr-2 and Ty-1.

Repository.—Holotype, OSU 28880; paratypes, OSU 4586, 4671, 19538, 19547 to 19549, 24559, 24596, 28872, 28881 to 28883, 28887, 28888, 28906 to 28908, 29161 to 29163, 29715 to 29720.

Temnocheilus quinqueliratus Sturgeon, 1946
Pl. 1-14, figs. 2-4

Temnocheilus pentaliratus Sturgeon, 1937, p. 358.
Temnocheilus quinqueliratus Sturgeon, 1946, p. 12, 21-22, pl. 6, figs. 1, 2.
Temnocheilus bellicosus Murphy, 1974, p. 742, 745 (in part).

Diagnosis.—Medium-sized, possibly immature temnocheilids having a subelliptical whorl section, rounded ventrolateral nodes, and five distinct longitudinal ridges on the internal mold; one midventral ridge and two between the nodes on each ventrolateral shoulder.

Material.—The holotype (OSU 18713) and a possible hypotype (OSU 28879) are the only known specimens. The holotype consists of almost one-half of an exfoliated whorl and is entirely part of the phragmocone. Its preserved length along the midventer is 70 mm, and the diameter of the conch must have exceeded 60 mm. The following approximate measurements and ratios of the holotype are available: D (est.) = 60 mm, H (approx.) = 13.5 mm, W (average) = 31 mm, W/D = 0.52, H/W = 0.44. The hypotype is of comparable size; its whorl widths are 35 to 40 mm. It is somewhat mashed inward and distorted across the dorsum and flanks and is covered by test across the venter.

Description.—Conch at lower limits of medium size, probably immature, tarphyceraconic, subdiscoidal approaching subglobose, regularly and gradually increasing in size throughout preserved portion; whorl section strongly depressed dorsoventrally, subelliptical in outline, being very broadly rounded ventrally, narrowly rounded laterally and dorsolaterally, probably slightly impressed dorsally; nature of early whorls, body chamber, and aperture unknown. Test completely exfoliated from holotype and preserved on venter of hypotype, approximately 1 mm thick, thickest in ventrolateral zones; surface marked adapically by strong growth lirae tracing a broad, rather shallow hyponomic sinus. Internal mold marked by longitudinal ridges, nodes, and sutures; a faint, broad, median longitudinal ridge along midventer and two parallel and somewhat stronger ridges separated by a conspicuous groove on each ventrolateral shoulder; these ventrolateral lines diminishing in size, but extending up to apices of ventrolateral nodes; a single row of nodes (estimated 10 to 12 per whorl and spaced 15 to 17 mm apart) on each ventrolateral shoulder, sharply pointed and about 4 mm high on holotype and more bluntly rounded and lower on hypotype, those on one shoulder slightly offset from those on the other; nodes extending laterally with a small ventral obliquity and forming a shallow concave zone between their apices and crown of venter. Septa moderately spaced (about 7 mm apart) on holotype, spacing orad indicating an immature individual; ratio of cameral length to whorl width between bases of nodes almost 1:4.5; sutures transverse and slightly sinuous, forming a very broad, shallow, rounded lobe across venter, a faint rounded saddle at ventrolateral shoulders, and straight courses across flanks and dorsolateral surfaces; unknown beyond; nature and position of siphuncle unknown.

Remarks.—In spite of being represented by fragmentary and immature specimens, this species can be readily recognized by its subelliptical whorl sections; large, widely spaced, rounded nodes; the five longitudinal ridges on the internal mold; and possibly its small size. The hypotype resembles *Temnocheilus annulonodosus* Sturgeon, Windle, Mapes & Hoare, but differs from that species in the possession of the two elevated lines on the ventrolateral shoulders and slightly shallower hyponomic sinus. The hypotype differs from the holotype in having blunter nodes and less rapid conch expansion. At first we suspected that our specimens of *T. annulonodosus* were examples of *T. quinqueliratus*, but exfoliation of the ventrolateral shoulders of several specimens revealed no elevated longitudinal ridges on their internal molds. The growth rate is also less than for the holotype of *T. quinqueliratus*. Murphy (1974, p. 742, 745) placed this species and *Temnocheilus* (*Latitemnocheilus*) *medioventralis* (Sturgeon) in synonymy with *T.* (*L.*) *bellicosus* (Morton). Although he has raised some pertinent considerations, we are presently unable to accept his opinion. Our reasons are given under remarks pertaining to *T.* (*L.*) *bellicosus*.

Occurrence.—2 specimens total; Putnam Hill unit: 1 questionable specimen from loc. Mc-2; Vanport unit: 1 specimen from loc. Tl-1.

Repository.—Holotype, OSU 18713; doubtful hypotype, 28879.

Genus *Latitemnocheilus* Sturgeon, Windle, Mapes & Hoare, 1982

Type species: *Nautilus (Temnocheilus) latus* Meek & Worthen, 1870; OD

Temnocheilus Miller, Dunbar & Condra, 1933, p. 156-160 (in part); Kummel, 1953, p. 17-18, fig. 8 (in part); 1964, p. K427 (in part).

Latitemnocheilus Sturgeon, Windle, Mapes & Hoare, 1982, p. 1465.

Diagnosis.—Large temnocheilids having mature subrectangular whorl sections.

Description.—Conch large, tarphyceraconic; umbilicus wide; mature whorl section subrectangular, being broadly flattened and slightly convex ventrally, flattened laterally, and slightly convex on umbilical walls, very obtusely rounded across dorsolateral zones, flanks and umbilical walls normally merging without a sharp line of demarcation, and slightly impressed dorsally (fig. 1-7K); earliest whorl stages rounded, intermediate stages subelliptical; surface marked by numerous growth lirae indicating a broad, deep hyponomic sinus, by strong longitudinal cuspate lines on early growth stages, and by longitudinal lirae on adult stages of some species; ventrolateral shoulders less obtuse than dorsolateral zones and bearing a single row of rounded or elongate and even confluent nodes; sutures normally having broad ventral, lateral, and dorsal lobes; siphuncle small, nearly central, and orthochoanitic.

Remarks.—Mature specimens of *Latitemnocheilus* can readily be separated from those of *Temnocheilus* and *Mahoningoceras* by their depressed subrectangular whorl sections. Adult specimens also tend to be larger than those of the other two genera; it is estimated that the largest ones in our collection attained maximum conch diameters up to 200 mm. Most North American Pennsylvanian forms previously referred to *Temnocheilus* probably should be placed in *Latitemnocheilus*. These include at least *Ammonites bellicosus* Morton, 1836; *Temnocheilus harneri* Miller & Owen, 1934; *T. johnsoni* Miller, Dunbar & Condra, 1933; *Nautilus* (*T.*) *latus* Meek & Worthen, 1870; *T. medioventralis* Sturgeon, 1946; *T. subrectangularis* Miller, Dunbar & Condra, 1933; and *N.* (*T.*) *winslowi* Meek & Worthen, 1870. No attempt is made to place generically the several Permian species of *Temnocheilus* described by Miller & Youngquist (1949, p. 94-96).

Geologic range.—Pennsylvanian-Permian.

Latitemnocheilus bellicosus (Morton), 1836
Pl. 1-16, figs. 2, 3

Ammonites bellicosus Morton, 1836, p. 150, pl. 3, fig. 8.

Goniatites bellicosus Weller, 1898, p. 291.

Temnocheilus bellicosus Murphy, 1974, p. 742, 745-746 (in part).

Remarks.—Because of brevity and incompleteness of Morton's description, variation between his two illustrations, and unavailability of type or topotype specimens, we believe that, although *Ammonites bellicosus* is a valid name, it is nevertheless an unrecognizable species. Morton's crude cut-away illustration does indicate that his specimens were representatives of *Latitemnocheilus*. This species was the first nautiloid cephalopod named and described from the Pennsylvanian System of Ohio and may include two species. The type material was collected from the Vanport unit at the Dugway between Putnam Hill and the Muskingum River in Zanesville, Muskingum County. Present location of the type material is unknown. Morton's description is very brief and inadequate; his illustrations are two woodcut figures herein reproduced as figures 2 and 3 of plate 1-16. These figures show the right side of a conch consisting of approximately three whorls (pl. 1-16, fig. 3) and an oblique cut-away cross-sectional view (pl. 1-16, fig. 2) of apparently another specimen. The reliability of these figures is uncertain, but if they are reasonably accurate, it appears that two species are shown. Morton's oblique cut-away figure (pl. 1-16, fig. 2) has 14 nodes per whorl and a more subquadrate whorl outline; the lateral-view figure (pl. 1-16, fig. 3) has 20 nodes per whorl and possibly a more rounded whorl profile. Although *Latitemnocheilus bellicosus* is a valid taxon, it will remain one of uncertain recognition until its original type material or certain and good topotype material becomes available. A specimen of *Latitemnocheilus* sp. (pl. 1-16, fig. 1) from undifferentiated Putnam Hill-Vanport units in Hopewell Township, Muskingum County, a short distance west of Morton's locality, might represent his species. Under the circumstances such a referral is too uncertain to be seriously considered.

Murphy (1974, p. 742, 745-746) has minimized the significance of variation among temnocheilid ventrolateral nodes and has identified all temnocheilids from the lower and middle Allegheny Group of Ohio as *Temnocheilus bellicosus* (Morton). From our observations on variations of whorl sections and nodes among approximately 60 available specimens from Allegheny and Pottsville strata, we are tentatively recognizing three genera and possibly as many as 10 species. We are cognizant of the possibility that several of our species may be synonyms, as observations on incomplete, distorted, and variably mature specimens place us in a situation similar to the blind men observing and describing an elephant by each feeling a different part of its anatomy. The basis for our decisions is that specimens can be anatomically distinguished from one another.

Occurrence.—2 specimens; Vanport unit: loc. MUsp-1.

Repository.—Unnumbered specimens (Morton's types), present location unknown.

Latitemnocheilus medioventralis (Sturgeon), 1946
Pl. 1-16, figs. 4, 5

Temnocheilus medioventralis Sturgeon, 1946, p. 12, 22-23 (in part), pl. 5, fig. 2; pl. 6, fig. 8.

Temnocheilus bellicosus Murphy, 1974, p. 742, 745-746 (in part).

Diagnosis.—Medium-sized to large *Latitemnocheilus* having a median ventral saddle and apparently without an annular lobe.

Material.—Two partially preserved specimens were originally assigned as syntypes to this species. One specimen (OSU 18714) was crushed and distorted and is no longer considered to be a representative of the species. The other specimen (OSU 18715) consists roughly of one-fourth of two whorls, has preserved almost 90 mm of midventral length along the outer whorl; W = 52 mm, H = 32 mm, and H/W = 0.62. It is herein designated the lectotype for the species.

Description.—Conch medium sized to large (for temnocheilids), moderately and gradually increasing in size; umbilicus wide and deep; whorl section strongly depressed dorsoventrally and subrectangular in cross section, being broadly and weakly convex ventrally with a flattened median zone, more narrowly rounded laterally, somewhat flattened on umbilical walls and depressed dorsally, approximately 20 mm wide and 2 mm deep at adoral end of specimen; ventrolateral and umbilical margins obtusely rounded, the former more angular at nodes and the latter with gradual separation between flanks and umbilical walls; angulation at umbilical seams also obtuse, maximum whorl width just below umbilical shoulders. Test ranging in thickness from less than 1 mm in ventral, lateral, and dorsolateral walls to 1.5 mm beneath ventrolateral surfaces and much thicker in ventrolateral nodes; surface marked by numerous growth lines faintly preserved on dorsolateral and umbilical surfaces; single row of rounded nodes on each ventrolateral shoulder. Septa nearly transverse to axis of whorl, extended slightly orad dorsally, moderately convex apicad, being rather uniformly convex dorsoventrally and somewhat flattened laterally in median area; sutures slightly sinuous and forming a broad, shallow median ventral saddle bordered by similar lobes on venter; ventrolateral saddle much stronger in nodes, broad lateral and dorsolateral lobe, narrow subangular saddle at umbilical seam, broad, rounded dorsal lobe, apparently no annular lobe; median ventral saddle less distinct or even absent on next inner whorl; siphuncle subcentral in position, slightly nearer dorsum, approximately 6 mm in diameter.

Remarks.—This temnocheilid is characterized by its medium to large size for the genus, subrectangular whorl section, a broad shallow midventral saddle, and apparent lack of an annular lobe. It differs from other known North American species of *Latitemnocheilus* as follows: *L. harneri* (Miller & Owen) is similar but appears to have more conspicuous nodes; until the suture pattern of that species is known, we are considering it as a separate species. *L. johnsoni* (Miller, Dunbar & Condra) has more confluent nodes and lacks a midventral saddle. *L. latus* (Meek & Worthen) and *L. subrectangularis* (Miller, Dunbar & Condra) also have more confluent nodes. Murphy (1974, p. 745-746) has questioned the significance of the midventral saddle, which we believe is the most distinctive feature of this species; he placed *L. medioventralis* in the synonymy of *L. bellicosus* (Morton). We are, however, continuing to recognize the integrity of the species until more convincing evidence to the contrary is available.

Occurrence.—1 specimen; Columbiana unit: loc. Mg-2.

Repository.—Lectotype, OSU 18715.

Latitemnocheilus cf. *L. harneri* (Miller & Owen), 1934
Pl. 1-17, figs. 1, 2; pl. 1-18, figs. 1, 2; pl. 1-19, figs. 1-3

Temnocheilus harneri Miller & Owen, 1934, p. 223-225, pl. 13, fig. 1, pl. 14, fig. 1; Hoare, 1961, p. 132, pl. 18, figs. 3-6.

Diagnosis.—Very large *Latitemnocheilus* having exceptionally well-developed subrectangular mature whorl cross section and large, conical, rounded, bluntly terminated ventrolateral nodes.

Material.—We have at least six incomplete individuals of very large specimens of *Latitemnocheilus* as well as numerous nodes and shell fragments probably representing the same species from the Putnam Hill unit. The largest of these must have had an approximate conch diameter of 180 mm, maximum whorl width of 100 mm, maximum whorl height of almost 70 mm, W/D ratio of 0.48, and H/W ratio ranging between 0.64 and 0.67. The most completely preserved specimen (OSU 28884, pl. 18, fig. 2) has a total length along the outer curvature of almost 205 mm. In addition, it shows the ventral apertural margin along the right side and the hyponomic sinus approximately 25 mm deep. Parts of two inner whorls also are preserved and attached to the outer whorl.

Description.—Conch very large, tarphyceraconic, subdiscoidal, consisting of at least three moderately rapidly expanded whorls; umbilicus normally wide, steep walled, deep, and perforate; perforation apparently nearly circular, 12 to 13 mm in diameter; outer whorls subpentagonal to subrectangular and depressed dorsoventrally, being convex overall ventrally, but having a flattened, concave median zone wider than lateral zones sloping outward toward ventrolateral shoulders, forming a concave area opposite each ventrolateral node and curving over internodal spaces; flanks nearly flat, slightly convex, passing over evenly rounded umbilical shoulders without definite line of separation onto flattened but also slightly convex umbilical wall, except for indentations accommodating nodes of next whorl; dorsum impressed, 28 mm wide and estimated 1 to 2 mm deep at a whorl width of approximately 70 mm; ventrolateral and umbilical shoulders and umbilical-seam angles obtusely rounded, the former more narrowly rounded and the latter very widely rounded. Test much exfoliated over two largest specimens, little more than 1 mm thick in umbilical area and upper portion of flanks, gradually becoming much thicker ventrally in ventrolateral zones and nodes, approximately 2 mm thick across venter; inner shell layers on partially exfoliated venter of most complete specimen (OSU 28884) having wrinkles following outline of hyponomic sinus; ventrolateral shoulders bearing a single row of 14 large, ventrolaterally extended, rounded, nonconfluent nodes, only slightly extended lengthwise to form subelliptical cross sections, and also extended dorsad onto flanks; crests of nodes on different specimens ranging from 20 to 33 mm apart and 7 to 14 mm high; nodes on most complete specimen (OSU 28884) diminishing in size and spacing orad, oldest visible whorl rounded in cross section and marked by longitudinal cuspate lines; rounded, separate nodes visible before end of first whorl, becoming high and rounded on second depressed whorl with subelliptical outline across flanks and dorsum. Septa rather strongly and evenly convex apicad, nearly transverse but slightly orad dorsally, especially in middle whorl; sutures somewhat sinuous, forming a very broad, shallow ventral lobe extending between ventrolateral shoulders, a narrowly rounded ventrolateral saddle, a rounded, somewhat accentuated lateral lobe on flanks, a very shallow and rounded saddle across umbilical shoulders and walls, and a rather pronounced dorsal lobe split in middle by a narrow but strong annular lobe; siphuncle nearly central in position, having a diameter of 5 to 6 mm in outer whorl and more than 2 mm in inner whorl.

Remarks.—The nodes of these specimens resemble very closely those of *Latitemnocheilus harneri* (Miller & Owen) and *L. winslowi* (Meek & Worthen). We have had opportunity to observe the type specimens of those two species. The holotype of *L. winslowi* (UC 6624) has certainly deteriorated since Meek and Worthen described it over 125 years ago (Meek and Worthen, 1870); it has been heavily covered with paraffin to prevent more damage. As far as can be observed, its nodes and whorl section resemble those features of the specimens under study. The holotype is, however, a much smaller individual (possibly immature) than our specimens and has a very rapid whorl expansion, although this feature may have been accentuated by the deterioration of the specimen. Unless satisfactory topotype material can be found, the best source of information concerning *L. winslowi* will remain Meek and Worthen's original description. Under the circumstances it is very difficult to evaluate their species and to compare our specimens with their holotype. Although *L. winslowi* is a valid species, several of its features are now uncertain because of the present condition of the holotype.

Latitemnocheilus harneri is much better represented by type material in a holotype and a paratype, but even so each of these specimens leaves much to be desired. The holotype (SUI 13398, pl. 1-17, fig. 2) is a three-whorled specimen considerably smaller than our specimens and preserved only on the right side and part of the venter, which is unfortunately much mashed and distorted. It too has been covered by a heavy coat of preservative to prevent oxidation of the pyritized portions of the specimen. The paratype (SUI 6172, pl. 1-17, fig. 1) is a somewhat fractured and distorted ventral part of a conch and is quite similar to one of our specimens (OSU 29247, pl. 1-18, fig. 1).

Unfortunately, we cannot observe and compare the internal features of either of the above species. It is possible that both *L. harneri* and our specimens are conspecific with *L. winslowi*, but until more and better specimens of Meek and Worthen's and Miller and Owen's species are available, this possibility cannot be verified. Hence we can only compare our specimens with theirs. If all three species prove eventually to be the same, Meek and Worthen's specific name has priority. If our specimens do prove to belong to an unnamed species, we suggest that a specific name in deference to their large size be given to them.

Occurrence.—8 specimens total; Putnam Hill unit: 3 specimens from loc. Ms-3, 2 specimens from loc. Vel-15, 1 specimen from loc. Ty-3; Cherokee Formation: 1 specimen each from locs. MO:Hfc-1 and MO:Vo-1.

Repository.—Holotype (*L. harneri*), SUI 13398; paratype (*L. harneri*), SUI 6172; OSU 28884 to 28886, 29247.

Latitemnocheilus cf. *L. johnsoni* (Miller, Dunbar & Condra), 1933
Pl. 1-19, fig. 4; pl. 1-21, fig. 2

Temnocheilus johnsoni Miller, Dunbar & Condra, 1933, p. 163-166, pl. 13, fig. 4; pl. 14, figs. 3, 4.

Diagnosis.—Medium-sized to large *Latitemnocheilus* having a widely depressed subrectangular whorl section and rather short, blunt, sturdy, asymmetrical ventrolateral nodes.

Material.—We have five incomplete specimens from the Lowellville (Poverty Run), Lower Mercer, and Putnam Hill units that resemble *Latitemnocheilus johnsoni* (Miller, Dunbar & Condra). The most complete specimen (OSU 29315), from the Lowellville (Poverty Run) unit, is a medium-sized, dorsoventrally mashed single whorl having an estimated original conch diameter at least of 80 mm and a probable maximum whorl width of 55 mm (60 mm to outside of the nodes). One Putnam Hill specimen (OSU 28902) has preserved only portions of the venter and the right ventrolateral shoulder including several nodes. This large individual has a preserved length of 90 mm and an approximate whorl width of 80 mm. Three very fragmentary specimens, each consisting of several nodes and pieces of shell, are from the Lower Mercer and Putnam Hill units.

Description.—Conch large, tarphyceraconic, whorls gradually expanded; whorl section much depressed and wide, H/W ratio approximately 0.60, subrectangular to subpentagonal in outline; venter apparently quite flat, but weakly convex with a median broad, flattened area and narrower lateral zones, the latter gently sloping toward ventrolateral shoulders except for concave areas adjacent to ventrolateral nodes; ventrolateral and umbilical shoulders obtuse, the former narrower and subangular, the latter wider and rounded; dorsum apparently moderately impressed. Test moderately thick, 1 to 2 mm on smaller specimen and 2 to 3.5 mm on larger one, thicker on flanks and much thicker in ventrolateral shoulders; ventrolateral shoulders locally elevated into low, asymmetrical, bluntly terminated, elongate, nonconfluent nodes projected outward and downward with gentler declivity onto venter and steeper ridgelike extension onto flanks; nodes (estimated 10 or more per whorl) spaced 15 to 20 mm apart on smaller specimen and 28 to 30 mm on larger example; surface ornament not well preserved, on larger specimen consisting of rather fine growth lines, some stronger and separated by larger furrows and tracing the outline of a very broad, rather shallow, rounded, V-shaped ventral sinus. Features of septa, sutures, and siphuncle not preserved.

Remarks.—These specimens are distinguished by their blunt, rather short, elongate but not confluent ventrolateral nodes and their depressed subrectangular whorl section. The whorl section resembles that of *Latitemnocheilus subrectangularis* (Miller, Dunbar & Condra), but differs in being larger and in lacking the confluent nodes and reticulate surface pattern of that species. Our specimens have definite similarities with *L. johnsoni* (Miller, Dunbar & Condra) in whorl section, nodes, and thickness of test, but differ in the lack of a midventral concavity. We have had opportunity to examine the type specimens of both these species and believe that our specimens are closer to *L. johnsoni*. We are not confident that they are conspecific. The test of specimen OSU 28902 has rounded elongate pits probably made by boring organisms of undetermined biologic affinity.

Occurrence.—5 specimens total; Lowellville (Poverty Run) unit: 1 specimen from loc. Tfr-1; Lower Mercer unit: 1 specimen from loc. Hfg-5; Putnam Hill unit: 1 specimen each from locs. HOh-1, Vel-15, and Vel-19.

Repository.—OSU 28902, 29315.

Latitemnocheilus cf. *L. latus* (Meek & Worthen), 1870
Pl. 1-12, fig. 1; pl. 1-14, fig. 6; pl. 1-20, figs. 1, 2

Nautilus (Temnocheilus) latus Meek & Worthen, 1870, p. 49; 1873, p. 608-609, pl. 30, figs. 2a, b.

Temnocheilus latus Kummel, 1953, p. 17-18, pl. 1, figs. 1, 2; fig. 8.

Diagnosis.—Large temnocheilids having a subrectangular whorl section, elongate and slightly confluent nodes, and a linear flattened to slightly concave zone occupying the middle one-third of convex venter bordered on each side by a wide, low, rounded ridge.

Material.—We have two specimens (OSU 28873, 29248) from the Putnam Hill unit, consisting of large ventral fragments, which we compared with the holotype (UI X 438A) of Meek and Worthen's species. The approximate measurements and ratios in table 1-11 have been determined mostly from the holotype. Other measurements for the holotype and a tentative hypotype, respectively, include maximum whorl width to outside of nodes, 96 and 104 mm; width of midventral zone (average), 30 mm for both; width of ven-

TABLE 1-11.—*Conch measurements and ratios of* Latitemnocheilus latus *and* Latitemnocheilus *cf.* L. latus

Specimen	D (est.) (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
UI X 438A (holotype)	130	72	50	82	0.63	0.61	0.55
OSU 28873 (holotype?)				85			

trolateral zones (on venter), 26 and 25 mm; average linear distance between ventrolateral node crests, 25 and 31 mm, and average height of ventrolateral nodes, 8 mm for both.

Description.—Conch medium sized to large, tarphyceraconic, subglobose; umbilicus deep and moderately wide; whorl markedly depressed, subrectangular, maximum width on flanks below or near umbilical shoulders (fig. 1-7K), being weakly convex and flattened ventrally with a noticeably flattened to concave band along median one-third of venter; central zone bordered on each side by low, broad, rounded ridge approximately 5 to 6 mm wide and 1 mm high, ridges less distinct orad; lateral parts of venter sloping outward with distinct concavity adjacent to nodes on holotype, obtusely rounded over dorsolateral zones and indistinct dorsolateral shoulders, more widely rounded over the latter; flanks nearly straight above ventrolateral nodes and sigmoidal across internodal areas, being concave above ventrolateral shoulders and convex toward and over umbilical shoulders, convexly rounded across umbilical wall, and presumably slightly impressed dorsally. Test 1 to 2 mm thick in ventral and lateral walls, a little thickened in ventrolateral shoulders, and much thickened in nodes; surface marked by numerous growth lirae of at least two sizes, coarser ones on venter 1 to 4 mm apart, probably averaging 2 mm, more crowded across noded ventrolateral shoulders, additional lirae apparently added by intercalation; lirae extended across venter in a broadly rounded tongue-shaped sinus about as wide as flattened central zone and approximately 25 mm deep, passing over ventrolateral shoulders in a much narrower and shallower salient orad, and across flanks and over umbilical shoulders onto umbilical wall in a rounded shallow concavity orad; faint traces of longitudinal lirae on venter of holotype; each ventrolateral shoulder possessing a row of elongate, weakly confluent, ventrolaterally extended nodes spaced 25 to 30 mm apart and offset, those on left side farther orad about one-half the length of a node, ventral margins nearly straight and extended in a rounded ridge across flanks to umbilical shoulders; nodes on older whorl apparently more rounded but definitely extended across flanks. No information available on internal features of conch.

Remarks.—The most distinctive feature of *Latitemnocheilus latus*, the type species for the genus *Latitemnocheilus*, is the size and configuration of the flattened to concave median ventral band bordered by a low but broadly rounded ridge on each side. *Latitemnocheilus johnsoni* (Miller, Dunbar & Condra) also has a flattened, concave median ventral zone, but has less distinct bordering ridges and blunter, sturdier nodes. One of our Ohio specimens (OSU 28873) has a flattened and slightly concave midventral zone and nodes similar to those of the holotype of *L. latus*, but differs in the absence of distinct ridges along that zone, in having a shallower and more V-shaped ventral sinus, and the nodes on the right side being farther orad. This specimen is a larger individual than the holotype, and on this specimen there is a definite tendency for a reduction in size of the ridges bordering the midventral zone toward the aperture. This reduction probably indicates that there is a tendency for those ridges to disappear on mature specimens. Our other specimen (OSU 29248) also has a shallower ventral sinus and very strong longitudinal lirae, at least on the sides of the venter; those on the holotype are quite faint. We are of the opinion that all or most temnocheilids have longitudinal lirae and that their absence or presence may be largely a matter of preservation. Meek and Worthen (1870) stated that there were about 16 nodes on each side of the outer whorl of the holotype, but our estimate is only 13 nodes on that whorl. Both the holotype and our specimen OSU 28873 have shells of the brachiopod *Crania* attached to their surfaces; our specimen also has holes of a boring organism in two of its nodes (pl. 1-12, fig. 1).

Although our specimens are in general similar to the holotype of *L. latus*, we are not confident that they are conspecific. Mention should also be made of *L. subrectangularis* (Miller, Dunbar & Condra) from the Kendrick shale of Kentucky, which has faint longitudinal ridges along its midventer, longitudinal lirae on its venter and flanks, and a subrectangular whorl section, but which has very elongate, confluent ventrolateral nodes. Our specimens are more similar to *L. latus* than are the Kendrick shale specimens, which we also have had the privilege to observe.

Occurrence.—3 specimens total, 2 questionable; Putnam Hill unit: 1 specimen each from locs. Ms-3 and Ty-3; Seville Limestone: 1 specimen from loc. IL:RIh-1.

Repository.—Holotype of *Latitemnocheilus latus* (Meek & Worthen), UI X 438A; OSU 28873, 29248.

Latitemnocheilus? sp. #1
Pl. 1-21, fig. 1

Diagnosis.—Large temnocheilids having flattened, slightly convex venter and prominent high, compressed ventrolateral nodes with elongate bases and nearly round terminations.

Material.—Two fragments (OSU 28904 and 28905) from the Washingtonville unit appear to be unique and may be a distinct species. Each is only a short piece of the right ventrolateral shoulder and adjacent portions of the venter; specimen OSU 28904 includes part of the midventer. A few approximate measurements are listed in table 1-12.

Description.—Assumed to be specimens of the genus *Latitemnocheilus* and to have the general characteristics of that genus; venter flattened, very slightly convex, possibly having a trace of a concavity along median zone and having very little slope toward ventrolateral shoulders; preserved ventrolateral shoulder nearly 90°, possibly modified by distortion; test averaging 2 mm thick, thickenings in ventrolateral shoulders and nodes; surface marked by numerous growth lines, separated by furrows two or three times wider than lirae, finer above ventrolateral shoulders; on smaller specimen, a half-dozen long lirae visible on and between nodes; nodes prominent, high, laterally compressed, and elongate, but nearly rounded in section distally and having a low, rounded, rather narrow connecting ridge between

TABLE 1-12.—*Conch measurements*[1] *of* Latitemnocheilus*? sp. #1*

Feature	Specimen OSU 28904	Specimen OSU 28905
Maximun length of fragment	95	55
Length along midventer	72	
Whorl width inside nodes	72[2]	
Whorl width outside nodes	87[2]	
Distance between node crests	29[3]	31
Height of nodes	11	10
Depth of hyponomic sinus	18	

[1] Measurements in millimeters.
[2] Approximate measurement.
[3] Average measurement.

them; extended, heavy, rounded diagonal ridge onto flanks of larger fragment, and a lesser ridge onto venter of smaller fragment; symmetrical in lateral view, slopes nearly equal in apicad and orad directions.

Remarks.—The much-flattened venter and prominent, laterally compressed, symmetrical, elongate ventrolateral nodes with well-rounded ends seem to be the distinctive observable features of these specimens. It is unfortunate that their limited preservation prevents observations of their other features and adequate comparisons with other American species.

Occurrence.—2 specimens total; Washingtonville unit: 1 specimen each from locs. CAr-2 and Ty-1.

Repository.—OSU 28904, 28905.

Latitemnocheilus? sp. #2
Pl. 1-21, fig. 4

Diagnosis.—Medium-sized to large presumed latitemnocheilids characterized by rather low, elongate, confluent ventrolateral nodes.

Material.—We have fragments of three medium-sized to large specimens from the Lower Mercer unit that probably represent the genus *Latitemnocheilus*. The largest one (OSU 29303) is mashed and has preserved an approximate length of 120 mm along a ventrolateral shoulder, including test with two nodes on 45 mm of this shoulder. The other two specimens (OSU 29313, pl. 21, fig. 4; and OSU 29314) are small fragments retaining only two nodes each.

Description.—Conch medium sized to large, questionably a latitemnocheilid. Test moderately thick (1 to 2 mm, thicker in nodes); surface apparently smooth, no traces of surface ornament preserved; ventrolateral nodes 5 to 8 mm high and 20 to 30 mm apart, spacing dependent in part upon size of specimen; nodes symmetrical or nearly so in long profile and asymmetrical in cross profile with steep, more abrupt ventral slopes and uniform, more gradual slopes onto flanks; nodes not only low but also narrow, elongate, and confluent, with low and somewhat indistinct connecting ridges. No other features preserved or exposed except traces of septa and sutures on mashed specimen (OSU 29303); details uncertain except septa spaced 3 to 5 mm apart.

Remarks.—These specimens are really of dubious generic position. On the basis of apparent ventrolateral position of the nodes and of seemingly flattened flanks, we are considering them as temnocheilids and are tentatively placing them in the genus *Latitemnocheilus*. If the nodes were lateral in position on narrow flanks, an alternate generic designation would be *Endolobus*. As already noted, it is difficult to differentiate between temnocheilid genera and *Endolobus* on fragmentary and distorted specimens.

Occurrence.—3 specimens total; Lower Mercer unit: 2 specimens from loc. LIho-1; 1 specimen from loc. Vel-26.

Repository.—OSU 29303, 29313, 29314.

Genus *Mahoningoceras* Murphy, 1974

Type species: *Nautilus* (*Gyroceras*?)
subquadrangularis Whitfield, 1882; M

Mahoningoceras Murphy, 1974, p. 746.

Diagnosis.—Medium-sized to large tarphyceraconic temnocheilids having subequal but slightly depressed subquadrate mature whorl cross sections, wide perforate umbilicus, longitudinal lirations on older portions of conch, and widely spaced slightly elongate to rounded ventrolateral nodes.

Remarks.—We refer the reader to our description below of the type species, *Mahoningoceras subquadrangulare*, as well as to Murphy's description for full details of the genus and the type species. The type species is represented only by the holotype (AMNH 7425 G) and one topotype (OSU 29714). We also are placing *Metacoceras pottsvillensis* Morningstar in *Mahoningoceras*. That species is redescribed below.

The longitudinal lines of the first third of the oldest whorl indicate relationship with the temnocheilids. This genus differs from other temnocheilid genera by its slightly depressed subquadrate whorl section, large umbilical perforation, distinctive elongate to rounded ventrolateral nodes, and generally smaller conch size. *Temnocheilus* restricted has a mature subelliptical whorl section; *Latitemnocheilus* is represented by larger specimens and has a distinctive depressed subrectangular mature whorl section and commonly elongate or confluent nodes. The recognition of relationship with other temnocheilids places *Mahoningoceras* in the family Koninckioceratidae and not in the family Grypoceratidae as Murphy surmised. When Murphy established this genus, we had in manuscript a proposed genus *Metatemnocheilus* to include *Metacoceras pottsvillensis* Morningstar as the type species and *Nautilus* (*Gyroceras*?) *subquadrangularis* Whitfield. Murphy's choice of *N.* (*G.*?) *subquadrangularis* as the type for the genus does not affect the generic concept nor the included species.

Geologic range.—Lower Pennsylvanian (Atoka-Pottsville).

Mahoningoceras pottsvillense (Morningstar), 1922
Pl. 1-14, fig. 5; pl. 1-21, figs. 3, 5, 6

Metacoceras pottsvillensis Morningstar, 1922, p. 269-270, pl. 16, figs. 7, 8.

Temnocheilus searighti Unklesbay & Palmer, 1958, p. 1073-1074, pl. 138, figs. 4-7.

Diagnosis.—Medium-sized temnocheilids characterized by slightly depressed whorl section, wide umbilicus, longitudinal ridges on oldest whorl, and prominent, widely spaced, rounded to slightly elongate ventrolateral nodes.

Material.—Only two specimens of this species are known. One is from the Lower Mercer unit of Ohio and has been described and illustrated by Morningstar (1922); the other one is from the Burgner Formation of Missouri and has been described and illustrated by Unklesbay and Palmer (1958). We have had opportunity to observe both specimens and believe that they represent the same species. The Ohio specimen (OSU 8995), an internal mold that retains traces of test, originally had more than two whorls, but only about one and one-fourth whorl remain. The preserved part is mostly phragmocone and is well exposed on its right side and venter. Spacing of the last septa and apparent diminution of the ventrolateral nodes indicate a mature individual. The Missouri specimen (UM 13997) is much smaller, consists of about one and one-fourth whorls, and is probably an immature individual. It is test covered and well exposed on its left side and along most of its venter. Dimensions and ratios of these two specimens are given in table 1-13. The ratio differences may be dependent upon changes in whorl profile with growth.

Description.—Conch medium sized, tarphyceraconic, subdiscoidal to discoidal; umbilicus wide, deep, steep walled and perforate; mature whorl section of holotype nearly equidimensional (fig. 1-7E), slightly wider than high, subtrigonal, resembling *Temnocheilus* in early portion, and subhexagonal to subquadrangular on body chamber; maximum width between umbilical shoulders; flanks, umbilical walls, and venter of phragmocone flattened but broadly convex; faint shallow groove on midventer of Missouri specimen, dorsal impression 7 to 10 mm wide and up to 2 mm deep; ventrolateral and umbilical shoulders obtuse, the former more rounded and the latter more obtuse and sharper. Test thin, approximately 1 mm thick, externally smooth except for very faint growth lines visible on umbilical wall and for 18+ prominent longitudinal lirae separated by broad, rounded troughs on oldest preserved one-half whorl or more; each ventrolateral shoulder having a row of 14 distinct, externally rounded (slightly elongate on internal mold), slightly offset nodes; oldest preserved portion of conch without nodes; youngest preserved part with last two or three nodes subdued. Internal mold smooth except for sharply pointed molds of nodes, outer margins of septa, and a faint midventral ridge marking presence of a conchal furrow on inside of shell. Septa spaced progressively farther apart from 4 to 8 mm toward aperture except the last two being only 4 mm apart; septa moderately convex apicad, slightly more sharply convex dorsally, nearly transverse, farther orad dorsally; sutures sinuous with broad, shallow ventral and lateral lobes, a narrower and more angular saddle at ventrolateral shoulders, nearly straight course across umbilical walls, and a rather sharp V-shaped dorsal lobe; siphuncle not well preserved or exposed, apparently nearly central or subcentral in position, diameter 2 to 3 mm at a position about midway along preserved part of conch.

Remarks.—The distinctive features of this species are its medium size, weakly convolute coiling, wide umbilicus, nearly equal whorl dimensions, faint midventral groove, longitudinal lines on early stages of the conch, and conspicuous, widely spaced, rounded nodes. Because it appears to be a mature specimen, it differs from *Mahoningoceras subquadrangulare* in overall size, wider spacing of nodes at comparable size, and in having a smaller umbilicus. Otherwise we would consider it as an immature stage of that species. Morningstar placed her representative of this species in the genus *Metacoceras*, and Unklesbay and Palmer identified their specimen as a new species, which they named *Temnocheilus searighti*. Its longitudinally lirate early whorl and its suture pattern definitely indicate affinities with *Temnocheilus*; its whorl section and nonconfluent nodes are more like those features of *Metacoceras*. Both specimens are very similar at the same stages of growth and they are undoubtedly in the same genus. Absence of a weak groove along the venter of the Ohio specimen may be explained by its absence of test, by its more mature stage of growth, by individual variation, or by a combination of these.

Occurrence.—2 specimens total; Lower Mercer unit: 1 specimen from loc. Lh-1; Burgner Formation: 1 specimen from loc. MO:JAj-1.

Repository.—Holotype, OSU 8995; hypotype, UM 13997 (formerly holotype of *Temnocheilus searighti* Unklesbay & Palmer).

Mahoningoceras subquadrangulare (Whitfield), 1882
Pl. 1-15, figs. 1, 2

Nautilus (*Gyroceras*?) *subquadrangularis* Whitfield, 1882, p. 232; 1891, p. 602-603, pl. 15, fig. 16; 1893, p. 487, pl. 11, fig. 16.

Metacoceras subquadrangularis Miller, Dunbar & Condra, 1933, p. 168.

Mahoningoceras subquadrangulare Murphy, 1974, p. 746-747, pl. 3, figs. 1, 2.

Diagnosis.—Medium-sized to large, loosely coiled temnocheilids having a wide umbilicus, large umbilical perforation, mature subquadrangular whorl section, absence of nodes on last half of outer whorl, and longitudinally lirate early growth stage.

Material.—H. C. Bowman collected the holotype, which until recently was the only known specimen, from the Lower Mercer limestone near Canfield, Mahoning County. The holotype is largely exfoliated on its exposed surfaces, a little mashed, and somewhat distorted, and its right side is embedded in dark limestone matrix. Its apicad end is not well exposed, and the left side of its aperture appears to be entire. Only a few approximate dimensions and one ratio can be determined: D = 140 mm, U = 87 mm, H = 41 mm, U/D = 0.62. The following description is based in part upon Whitfield's complete and excellent original description and in part upon our observations of the holotype.

Description.—Conch large, consisting of more than two whorls, tarphyceraconic, discoidal; umbilicus wide and shallow, umbilical perforation very large (about 25 mm in diameter); most of oldest whorl rounded in cross section and more than first one-third marked by discernible longitudinal lines; flanks and presumably venter becoming flattened before end of first whorl; part of outer whorl a little mashed inward along flanks but apparently nearly equidimensional and subquadrangular, venter convex; obtusely angular ventrolateral shoulders may be accentuated by distortion and mashing, as portion nearest aperture appears to be

TABLE 1-13.—*Conch measurements and ratios of* Mahoningoceras pottsvillense

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
OSU 8995 (holotype)	80	51	27	29	0.36	0.93	0.64
UM 13997[1] (holotype)	43	25	16	20	0.48	0.78	0.58

[1] Holotype of *Temnocheilus searighti* Unklesbay & Palmer.

rounded both laterally and over these shoulders; flattened flanks diverging dorsally, maximum whorl width at lower margin of obtusely rounded umbilical shoulders; umbilical walls narrow, steep, overhanging, more gently sloping and wider apicad; lateral margins of aperture extended forward just below umbilical shoulders and most likely extended apicad ventrally into a hyponomic sinus. Test largely exfoliated, not well preserved, apparently thin; traces of growth lines near aperture; ventrolateral shoulders elevated into a single row of rather low, somewhat elongate nodes having steeper orad slopes and extending along those shoulders for approximately two-thirds of inner whorl and one-third of outer whorl; phragmocone occupying one-third of outer whorl. Septa visible only in nearly transverse sutures, apparently moderately convex apicad and spaced 3 to 4 mm apart on orad portion of inner whorl and 5 to 6.5 mm apart on outer whorl, more closely spaced dorsad, no closer spacing adjacent to body chamber; sutures sinuous, forming a broad ventral lobe, a rather narrowly rounded ventrolateral saddle, and a broad, shallow, asymmetrical lateral lobe extending across umbilical wall apparently to a saddle at umbilical seam; dorsal portion of suture and siphuncle not visible.

Remarks.—The synonymy for this taxon lists four different genera and subgenera in which this species has previously been placed. In addition, Murphy (1968, p. 2) used the generic name *Domatoceras* in a presentation at the annual meeting of the Ohio Academy of Science. We would have retained this taxon in the genus *Domatoceras* were it not for the longitudinally lined initial portion of the oldest whorl, a feature which, along with the manner of coiling and ventrolateral nodes, is distinctive of temnocheilids. Its nearly equidimensional whorl section, mature disappearance of nodes on the outer whorl, and large umbilicus indicate its position in the genus *Mahoningoceras*, of which it is the type species. *Mahoningoceras subquadrangular*e differs from *M. pottsvillense* (Morningstar) in having a larger adult size and a larger umbilical perforation and in having smaller, more elongate, and, at comparable growth stages, more closely spaced ventrolateral nodes. The loss of nodes on the outer whorl suggests maturity, but spacing of septa adjacent to the body chamber does not. Apparent lack of septa in parts of the holotype's phragmocone is undoubtedly due to destruction during fossilization.

Occurrence.—2 specimens; Lower Mercer unit: loc. Mc-4.

Repository.—Holotype AMNH 7425 G; topotype, OSU 29174.

Genus *Ungeroceras* Sturgeon & Miller, 1948

Type species: *Ungeroceras ungeri* Sturgeon & Miller, 1948; OD

Ungeroceras Sturgeon & Miller, 1948, p. 75-76; Teichert, 1964, p. K488.

Kionoceras ungeri Murphy, 1966, p. 1388-1390, figs. 1, 3.

Diagnosis.—Large gyroceraconic conchs exceeding 200 mm in diameter at maturity and possessing flattened and dorsally convergent flanks; early growth stages having both transverse and longitudinal ornament forming a reticulate pattern.

Remarks.—Because *Ungeroceras* is monotypical, details of its description are presented under *Ungeroceras ungeri* Sturgeon & Miller. When *Ungeroceras* was established, the holotype was the only known specimen, but subsequent collecting has added additional specimens. In 1966 Murphy (p. 1388) suppressed the genus as a junior synonym of *Kionoceras* Hyatt. Additional specimens have since shown that the holotype and Murphy's specimens are incomplete and immature, and that *Ungeroceras* is in reality a large gyroceraconic genus. Hence, Murphy's change in generic designation was most certainly a misapprehension of the true nature of the genus that was not known at that time. *Kionoceras* as now interpreted includes: ". . . apically curved, longitudinally fluted orthocones of circular to subcircular section." (Sweet, 1964, p. K229). Ornament of earliest preserved growth stages of available specimens and nature of the siphuncle of our holotype are features in common with those of *Kionoceras*, but most other features do not indicate a close relationship. We presently believe, on the basis of the evidence, that *Ungeroceras* is a representative of the Nautilida rather than the Orthocerida. The early growth stages of *Ungeroceras* suggest a possible relationship with Miller and Garner's (1953, p. 118-120, fig. 2) nautilid genus *Chouteauoceras* of the family Trigonoceratidae Hyatt from the Lower Mississippian of Michigan and Missouri. That genus is loosely coiled and has longitudinal markings, dorsally convergent flanks, and dorsal and ventral saddles.

An enigma is the fact that only the holotype of *Ungeroceras ungeri* has transverse lateral ribs. Possible interpretations are individual variation, sexual dimorphism, differences in preservation, different species in the genus, or homeomorphy of different forms. Because the specimens do have most conch features in common and because all specimens are from essentially the same stratigraphic source, we are inclined to favor one of the first three possibilities and to retain all available specimens, with one exception, in *U. ungeri*. The exception is a specimen illustrated by Murphy (1966, p. 1389, fig. 2), which most likely belongs to some orthocerid genus.

Geologic range.—Middle Pennsylvanian (lower Allegheny).

Ungeroceras ungeri Sturgeon & Miller, 1948
Pl. 1-22, figs. 1-6

Ungeroceras ungeri Sturgeon & Miller, 1948, p. 76, pl. 18, fig. 2.

Kionoceras ungeri Murphy, 1966, p. 1388-1390; figs. 1, 3.

Diagnosis.—Same as for the genus.

Material.—There are at least 13 specimens from the Putnam Hill and Vanport units and a possible one from the Columbiana unit. No specimen is complete; all of them lack both apical and apertural extremities and most are also more or less flattened. The holotype (OSU 19602) is a small part of an immature conch measuring about 50 mm along its outer curvature. It is somewhat mashed and embedded in matrix along its left side, but its exposed right side seems to be undistorted. Its whorl height and width cannot be determined exactly, but are subequal, the height being a little more than width. We were able to partially section the holotype and to determine the position and nature of the siphuncle. The largest specimens have conch diameters of more than 200 mm. One specimen (OSU 28920) is only exposed on its left side and is largely exfoliated, but we were able to determine the following approximate conch and whorl measurements and ratios: $D = 180$ mm, $U = 102$ mm, $H = 45.5$ mm, $W = 40$ mm, $W/D = 0.22$, $H/W = 1.14$, $U/D = 0.60$.

Description.—Conch large (diameter exceeding 200 mm), discoidal, gyroceraconic, consisting of more than one and apparently less than two moderately expanding whorls; "umbilicus" extremely wide; whorl section slightly compressed, nearly subequal, a little higher than wide, maximum width below median line of flanks; earliest preserved portion of conch subcircular to subelliptical in whorl outline, more narrowly rounded dorsally and ventrally than laterally, slightly flattened laterally and convergent dorsad, approaching a subtrapezoidal outline, flattening more pronounced on larger specimens, dorsolateral and ventrolateral zones becoming more distinct; venter becoming nearly flat but remaining slightly convex, dorsum moderately rounded, approximately two-thirds as wide as venter, ventrolateral and dorsolateral shoulders obtusely rounded, the latter more so. Test moderately thick, thickest on lower areas of flanks and ranging approximately from 1 mm on smaller specimens to 4 mm in flanks of largest specimens; surface marked by numerous fine growth lirae and a few stronger ones about 2 mm apart; lirae apparently weaker on mature parts of largest specimens, tracing a shallow, wide, broadly rounded ventral sinus, a strong, broadly rounded ventrolateral salient, a smaller and shallower sinus above, and a nearly straight course onto dorsal surface; earliest preserved growth stages having 25+ narrowly rounded to almost cuspate longitudinal ridges separated by rounded and wider troughs, and, on holotype, by lateral transverse ribs following pattern of growth lines, ribs diminishing in size and disappearing orad; nodes formed on ventrolateral zones at intersections of longitudinal ridges and transverse ribs (pl. 1-22, fig. 2). Septa and sutures visible on holotype (OSU 19602) and on hypotypes (OSU 28877 and 28920), 2 to 2.5 mm apart on holotype and 8 to 11 mm apart along venter on much larger hypotype (OSU 28920), except the last two orad only 6.5 mm apart, probably indicating a mature specimen; septa moderately convex apicad, slightly oblique, being farther orad on dorsum; sutures partially visible; on OSU 19602 and on OSU 28920 tracing nearly straight courses across venter, and on OSU 28877 forming a widely flaring, rounded, V-shaped ventral lobe; shallow, broadly rounded lateral lobes becoming more pronounced and asymmetrical orad and forming a moderately high, broadly rounded dorsal saddle; siphuncle known only in immature holotype, rather small, suborthochoanitic, ventrad, located 3 mm or one-third of distance above venter, inside diameter about 1 mm, less at passage through a septum; septal necks short, slightly curved outward, connecting rings slightly inflated but essentially straight and cylindrical, a little larger in diameter than that of septal necks.

Remarks.—Characteristic features of this species are also those of the genus and include large size, gyroceraconic coiling, subtrapezoidal rounded whorls that have flattened flanks converging dorsad, distinct transverse growth lines that become less definite orad on largest specimens, earliest preserved growth stages that have approximately 25 longitudinal ridges separated by rounded and wider troughs crossed on holotype by lateral ribs, septa that are slightly oblique dorsad, sutures on immature individuals that have a strong ventral lobe and a moderate dorsal saddle, the ventral lobe becoming nearly straight in mature conchs, and a suborthochoanitic subcentral siphuncle. Our knowledge of this genus and species in respect to size, manner of coiling, surface ornament, septa, sutures, and siphuncle has been much increased from the more recently collected hypotypes and by further preparation of the holotype. This additional information indicates that *Ungeroceras* is a valid genus and that Murphy's placing (1966, p. 1388) it in the synonymy of *Kionoceras* was based upon incomplete understanding of *Ungeroceras* at that time. Because the early growth stages of *Ungeroceras* resemble rather closely the features of the Lower Mississippian genus *Chouteauoceras*, we are tentatively assigning *Ungeroceras* to the nautilid family Trigonoceratidae. The reasons for this assignment are given under the generic remarks.

Occurrence.—15 specimens total; Columbiana or Vanport unit: 1 questionable specimen from loc. Pcl-1; Putnam Hill unit: 7 specimens from loc. Vel-15; 2 specimens from loc. Ms-3; 1 specimen each from locs. Mc-2, Mg-3, and Sc-5; Putnam Hill-Vanport units undifferentiated, 1 specimen from loc. Td-4; Vanport unit: 1 questionable specimen from loc. PA:Bb-1.

Repository.—Holotype, OSU 19602; hypotypes, OSU 28874 to 28878, 28920, USNM 155816, 155818.

Genus *Domatoceras* Hyatt, 1891

Type species: *Domatoceras umbilicatum* Hyatt, 1891; SD, Miller, Dunbar & Condra, 1933

Domatoceras Hyatt, 1891, p. 342-343; 1893, p. 440-441; 1900, p. 525; 1913, p. 606; Miller, Dunbar & Condra, 1933, p. 215-218; Miller & Owen, 1934, p. 222, 241-242, figs. 2A, 5A, B; Miller & Youngquist, 1949, p. 41-44, figs. 5A, B, 6I; Turner, 1954, p. 306, 315, pl. 25, figs. 1, 2, fig. 1e; Kummel, 1964, p. K400, K433, figs. 313, 1a-c; Windle, 1970, p. 72-74.

Grypoceras (Domatoceras) Kummel, 1953, p. 54-55.

Diagnosis.—Subdiscoidal grypoceratids having compressed mature whorls; flattened venter and flanks, the latter convergent ventrad; and rounded to subangular shoulders, with or without nodes.

Description.—Conch tarphyceraconic, subdiscoidal to discoidal; whorl section unequally subhexagonal; venter, flanks, and umbilical walls flattened; venter and umbilical walls slightly convex, flanks definitely convergent ventrad, dorsum weakly impressed; ventrolateral shoulders narrowly and obtusely rounded, umbilical shoulders more broadly rounded (fig. 1-7C); mature shoulders with or without nodes, nodes rare on umbilical shoulders. Suture pattern having rounded ventral, lateral, and dorsal lobes separated by ventrolateral and dorsolateral saddles; siphuncle small, subcentral, and orthochoanitic.

Remarks.—Kummel (1964, p. K400) suggested that *Domatoceras* Hyatt and other closely related grypoceratid genera were derived from Mississippian and Devonian centroceratids. Although the ancestry of the genus is somewhat doubtful, it is quite certain that *Domatoceras* did give rise to *Stearoceras* Hyatt, *Stenodomatoceras* Ruzhencev & Shimansky, *Stenopoceras* Hyatt, and *Titanoceras* Hyatt during the Pennsylvanian Period and to *Grypoceras* Hyatt and *Menuthionautilus* Collignon in Late Permian and Triassic times. Evolutionary changes among these genera are listed below.

Grypoceras: more involute conch, annular lobe;
Menuthionautilus: smaller umbilicus, convex mature venter, mature flanks nearly parallel, siphuncle ventrad;
Stearoceras: mature depressed whorl section;
Stenodomatoceras: smaller umbilicus, more compressed subtrapezoidal whorl section;
Stenopoceras: small or closed umbilicus, much-compressed whorl section, prominent dorsolateral saddle;
Titanoceras: subquadrate whorl section, concave venter,

numerous small elongate ventrolateral nodes.

Evolutionary trends in *Domatoceras* include more compression and increased height of mature whorl sections, greater involution of the whorls, and reduction in size of the umbilicus. Among our testiferous specimens the ventrolateral nodes tend to be elongate, connected by a carina, and semicircular in side view and forming a scalloped pattern in ventral view. Some specimens have a definite concave venter.

Review of the various species assigned to *Domatoceras* reveals a broad range in conchal details among them. Turner (1954, p. 315) supported the concept that the present genus should be interpreted in close accord with the type species, *D. umbilicatum*. The holotype of that species is an internal mold whose shoulders lack any evidences of nodes. Turner suggested that nodose forms should be placed in *Pseudometacoceras* Miller, Dunbar & Condra, currently regarded as a synonym of *Domatoceras*, except those nodose species referable to *Stenodomatoceras*. Most observers, including ourselves, have not followed Turner's suggestions, although it is apparent that *Domatoceras* and related genera need a careful and thorough review for possible revisions. Representatives of *Domatoceras* are known from Pennsylvanian and Permian rocks from all continents except Antarctica. In the United States, Pennsylvanian forms are known from the Midcontinent region (Miller, Dunbar, and Condra, 1933; Miller, Lane, and Unklesbay, 1947) and the Eastern Interior Basin (Meek and Worthen, 1873). Ohio representatives have been reported from the Pottsville Group (Morningstar, 1922; Sturgeon and Miller, 1948), the Allegheny Group (Sturgeon, 1946; Murphy, 1970), and the Conemaugh Group (Windle, 1970). Specimens have also been reported from western Pennsylvania (Miller and Unklesbay, 1942b) and from Maryland (Swartz, Price, and Bassler, 1919). Permian forms in the United States are known from Colorado, New Mexico, and West Texas (Miller and Youngquist, 1949).

Geologic range.—Pennsylvanian-Permian.

Domatoceras obsoletum Sturgeon, 1946
Pl. 1-23, figs. 1-5

Domatoceras obsoletum Sturgeon, 1946, p. 12, 30-31, pl. 8, figs. 1-3.
Domatoceras williamsi Hansman, 1958, p. 88 (in part).
Metacoceras obsoletum Murphy, 1974, p. 747, pl. 3, figs. 3, 4.

Diagnosis.—Small *Domatoceras* having subequal cross section of mature whorls, carinate umbilical shoulders, and abrupt disappearance of the numerous small, elongate ventrolateral nodes on adoral portion of mature conchs.

Material.—All eight specimens are from the Columbiana unit at nearby localities along Middle Fork Little Beaver Creek in Columbiana and Mahoning Counties just east of Salem. Although lacking both adapical and adoral extremities, the holotype (OSU 18726) is nearly complete on its right side and appears to have been a mature or nearly mature individual. A paratype (OSU 18727) and a topotype (OSU 19542) are polished long sections; both are immature specimens, and the paratype is incomplete. Another paratype (also OSU 18727) has been cut twice transversely and polished. The following measurements are based on the holotype and were taken near the adoral end and directly across the umbilicus to the opposite side: D = 68 mm, U = 31.6 mm, H = 17.6/21.9 mm, W = 20.4/23.6 mm, W/D = 0.35, H/W = 0.86/0.92, U/D = 0.46. Three measurements of the whorl on the transversely cut paratype ranged from 23 to 24.8 mm for height and 25.4 to 29 mm for width; H/W ratios ranged from 0.81 to 0.90.

Description.—Conch medium sized but small for *Domatoceras*, tarphyceraconic, discoidal, regularly and gradually expanded in size; umbilicus moderately wide, steep walled, stepped, and perforate, perforation large, subelliptical, and pointed at one end; whorl section slightly depressed to approaching equidimensional, irregularly hexagonal in cross section, being much flattened to slightly convex on ventral, lateral, and umbilical surfaces and weakly impressed dorsally; venter definitely convex in earlier stages of growth and becoming flattened, even slightly depressed, along median zone on adoral part of outer whorl; ventrolateral and dorsolateral shoulders and umbilical seams obtuse; ventrolateral shoulder rounded both externally and internally except through nodes; dorsolateral shoulder rounded internally and elevated outside into a carina which disappears on last half of outer mature whorl; umbilical seams rounded internally and uncertain externally, dorsal impression estimated to be approximately 2 mm deep and 12 mm wide. Test very thin (maximum average thickness 0.5 mm), slightly thicker in nodes and dorsal wall; ornamented by numerous fine growth lirae, stronger lirae and grooves at intervals of 2 to 3 mm on some portions of test, following nearly straight courses on umbilical walls and upper portion of flanks, and there turning apicad at first gently and then more definitely on ventrolateral shoulders and venter to form a rather deep, rounded, V-shaped sinus; very faint and locally wavy longitudinal lirae present at least on midventer; single row of numerous nodes (estimated to be almost 30 per volution) on ventrolateral shoulders; nodes small, elongate, compressed, offset, almost continuous in ventral view, terminated abruptly and absent on last preserved 28 mm of holotype, suggesting a mature or nearly mature conch. Septa visible only on sectioned specimens (OSU 18727 and 19542); partial sutures visible through thin shell of holotype; septa of holotype and of topotype not occupying last third of outer whorls, indicating a body chamber at least of that length; 11 camerae in a distance of 65 mm along venter of holotype; septa rather gently convex apicad, less so in early stages of growth and more so dorsally, extended farther orad ventrally; sutures only partly visible, having broad, rounded ventral and lateral lobes, narrowly rounded ventrolateral and dorsolateral saddles, and nearly straight course across the umbilical wall; siphuncle small, orthochoanitic, and definitely ventrad.

Remarks.—This species can be recognized by its small size, weak involution of its whorls, slightly depressed to equidimensional whorl cross section, carinate umbilical shoulder, and abrupt termination of the numerous small, elongate ventrolateral nodes on the adoral portion of mature conchs. The disappearance or reduction in size of nodes toward the aperture is a common feature on mature conchs of many species of *Domatoceras*, *Metacoceras*, and other genera, but is normally gradual rather than abrupt. The whorl section appears to resemble cross sections of certain representatives of *Metacoceras*, and Murphy (1974, p. 747) transferred this species to *Metacoceras*. It is a borderline example, and decisions of generic position are based on subjective preference. We still prefer to retain it in *Domatoceras* for the following reasons. The H/W ratios of *D. obsoletum* are 0.85 to 0.90, and those of our several species of *Metacoceras* range from 0.55 to 0.70, with the possible exception of *Metacoceras* sp. #2. These figures place *D. obsoletum* within the lower range of *Domatoceras* and well above those for most examples of *Metacoceras*. The ventrolateral nodes of *Domatoceras* tend to project ventrally, to be elongate, and to form a wavy carina on each shoulder in ventral view. Those of *Metacoceras* tend to project laterally or ventrolaterally, to be more rounded, and normally not to be part of a carina. The nodes of *D. obsoletum* resemble more those of *Domatoceras*. We believe that available evidence supports retention in the genus *Domatoceras*. We are also doubtful of Murphy's citation (1974, pl. 3, fig. 3) as a representative of this species. The nodes on that specimen do not appear to be typical for the species, but we cannot be certain unless we see the specimen.

Occurrence.—8 specimens total; Columbiana unit: 6 specimens from loc. Mg-2; 1 specimen each from locs. Cp-3 and Mg-10.

Repository.—Holotype, OSU 18726; topotype, OSU 19542; paratypes, 18727, 29258.

Domatoceras oreskovichi Sturgeon, Windle, Mapes & Hoare, 1982

Pl. 1-23, figs. 6, 7; pl. 1-24, figs. 2, 3;
pl. 1-26, figs. 1, 2; pl. 1-27, figs. 1-6

Domatoceras sp. Sturgeon?, 1946, p. 32, pl. 8, fig. 4.
Domatoceras sculptile Murphy?, 1970, pl. 36, fig. 7.
Domatoceras oreskovichi Sturgeon, Windle, Mapes & Hoare, 1982, p. 1468-1469, pl. 2, figs. 6, 7, 9; pl. 3, fig. 2.

Diagnosis.—Large to very large discoidal *Domatoceras* having small involution; wide, shallow, steep-walled perforate umbilicus; concave venter; and numerous elongate confluent ventrolateral nodes.

Material.—We have numerous fragmentary but recognizable specimens of a large, widely umbilicate *Domatoceras* similar to *D. williamsi* Miller & Owen, but different from that species in several significant features. Most of our specimens are from the Putnam Hill unit, primarily from the pits of the former Keller Mines, Inc., in Mahoning County near Alliance. Except for several individuals consisting of part of the body chamber and one camera of the phragmocone, all our specimens are mashed laterally, so that no single specimen provides all the usual dimensions and ratios. The measurements in table 1-14 are based upon the holotype and six paratypes. These few data do not establish a broad basis for comparison, but do suggest H/W ratios of 1.05 to 1.18 and U/D ratios of 0.48 to 0.50, which correlate quite well with those ratios for *Domatoceras williamsi*.

Description.—Conch large to very large (estimated maximum diameter of about 150 mm), weakly involute, tarphyceraconic, discoidal, consisting of at least three-and-a-half whorls; umbilicus wide, shallow, slightly gradate, steep walled, and apparently perforate; mature whorl section compressed, somewhat higher than wide, irregularly subhexagonal in cross section, venter concave both inside and outside of test, more so externally; flanks flattened but definitely convex, convergent ventrad, maximum whorl width at or just below umbilical shoulders; steeply sloping umbilical walls flattened, slightly sigmoidal, being a little distended adjacent to umbilical shoulders, concave below and elevated into a narrowly rounded carina at umbilical seam; dorsum 16 mm wide at a whorl width of 40 mm, impressed approximately 2.5 mm; ventrolateral shoulder acutely rounded internally and umbilical shoulder obtusely rounded internally, no sharp boundary between flanks and umbilical walls; angles at umbilical seams also obtuse, raised into a rounded narrow ridge; earliest whorl not well preserved, rounded, subcircular in cross section, exquisitely marked by numerous fine transverse growth lines; second whorl having lateral and ventral flattening, dorsolateral shoulders apparent before ventrolateral angulations and carinae, first appearance of ventrolateral nodes near end of second whorl. Test preserved in white aragonite in some specimens, pyritized in others, and calcitic in still others, variable in thickness, ranging from less than 1 mm in dorsal and midventral areas to more than 3 mm in upper lateral and dorsolateral portions; growth lirae on surface of mature whorl of two strengths, noticeably separated at approximately 4-mm intervals, outlining a deep, widely rounded ventral sinus, an obliquely outward and orad course across the ventrolateral shoulders, a sigmoidal path with a ventral shallow rounded salient, a shallower dorsal concavity across flanks, and a nearly straight but slightly convex orad trend across umbilical walls; midventral concavity and possibly flanks marked by less conspicuous longitudinal lirae; rounded ventrolateral carinae becoming nodose near end of second whorl; ventrolateral nodes numerous (estimated 35± per mature whorl), rounded in side view, more extended ventrad than laterally, also longitudinally elongate and confluent, diminishing in size and disappearing orad on outermost whorl of largest specimens (pl. 1-26, fig. 2). Internal mold smooth except for a weak, rounded midventral ridge indicating a small shallow conchal furrow, sutures, and subdued replicas of ventrolateral nodes. Septa nearly transverse to whorl axis, slightly farther orad dorsally, rather strongly convex apicad dorsoventrally, and evenly and moderately convex laterally; mature suture pattern consisting of a moderately deep, rounded ventral lobe, subangular rounded ventrolateral saddles, very broadly rounded lateral lobes merging into an indistinct saddle across umbilical walls, a sharply rounded saddle at umbilical seams, and a deep, rounded dorsal lobe (fig. 1-8A); siphuncle slightly ventrad, on holotype being 18 mm from venter and 22 mm from dorsum, subelliptical in cross section, 3.2 mm high and 2.3 mm wide, possibly a little distorted, questionably orthochoanitic in structure.

TABLE 1-14.—*Conch measurements and ratios of* Domatoceras oreskovichi

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	H/W	U/D
OSU 29138 (holotype)			42.3	40	1.05	
OSU 29139 (paratype)			40	35.5	1.13	
OSU 29140 (paratype)	112.9	54				0.48
OSU 29141 (paratype)	152[1]	77[1]				0.50[1]
OSU 29142 (paratype)	133	64				0.48
OSU 29144 (paratype)			38	32	1.18	
OSU 29156 (paratype)			39.5	36	1.10	

[1] Approximate measurement.

Remarks.—*Domatoceras oreskovichi* is very similar to *D. williamsi* Miller & Owen in amount of involution and in having a wide perforate umbilicus, similar H/W and U/D ratios, numerous ventrolateral nodes on mature whorls, and similar suture patterns, but differs in being a little larger, in having steeper umbilical walls, a smaller umbilical perforation, and more numerous ventrolateral nodes, and in lacking dorsolateral nodes and lateral ribs on mature whorls. The

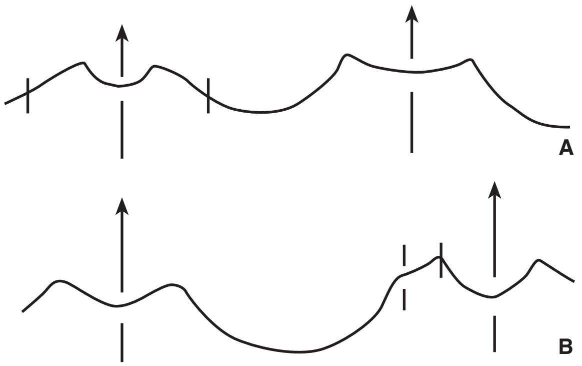

FIGURE 1-8.—Diagrammatic illustrations of mature suture patterns of two species of *Domatoceras*; both X1.

A, *Domatoceras oreskovichi* Sturgeon, Windle, Mapes & Hoare. Suture pattern based on holotype; Putnam Hill unit, loc. Ms-3; OSU 29138 (also see pl. 1-23, figs. 6,7).

B, *Domatoceras williamsi* Miller & Owen. Suture pattern based on a syntype (now a paralectotype); Cherokee Formation, Henry County, Missouri; SUI 13417. After Miller and Owen (1934). Right and left reversed from current practice.

two species probably are closely related and possibly are homeomorphs. Miller and Owen (1934) noted that other similar species include *Domatoceras mosquense* (Tzwetaev), *D. sculptile* (Girty), and *D. umbilicatum* Hyatt, but they were unable to make any definite decision on relationship among those three species and with *D. williamsi*. Other American species of *Domatoceras* are more involute, have higher and more compressed or more subquadrate whorl sections, or are based upon immature specimens.

We have another similar but undescribed specimen from Desmoinesian strata near Knoxville, Iowa; this specimen has a wide, shallow, perforate umbilicus and more numerous ventrolateral nodes that appear at an earlier growth stage than they do on *D. oreskovichi* and *D. williamsi*. Species assignment of this specimen must await further analysis.

A specimen (USNM 161420) from the Columbiana shale in Mahoning County which Murphy (1970, p. 202, pl. 36, fig. 7) identified as *D. sculptile* (Girty) we are referring questionably to *D. oreskovichi*. We have examined this specimen and have compared it with Girty's *D. sculptile* type specimens from the Wewoka Formation of Oklahoma. There are several differences between the Ohio specimen and those from Oklahoma; the most significant difference is the presence of ventrolateral nodes on the internal mold of the inner exposed whorl of the Ohio specimen. At similar stages of growth, the types of *D. sculptile* have an essentially smooth carina on each ventrolateral shoulder. Its incompleteness and manner of preservation do not permit positive assignment of the Columbiana specimen, but we are quite certain that it is not a representative of *D. sculptile*.

A Putnam Hill specimen (OSU 29155) collected near Canfield, Mahoning County, has a half-dozen small inarticulate brachiopods and numerous serpulid? worm tubes attached to its right side. Their occurrence on only one side probably indicates that the conch was on the sea bottom for some time after its death and before its burial by sediments. The brachiopods appear to be internal molds of immature specimens of either *Lindstroemella* sp. or *Orbiculoidea* sp.

This species is one of our more abundant ones in terms of numbers of individuals; unfortunately, all of them are fragmented and many are distorted. The strip pits of the former Keller Mines, Inc., in Smith Township, Mahoning County, near Alliance (loc. Ms-3), have been the most prolific source from the Putnam Hill unit. The specific name was given in appreciation to John Oreskovich, who operated Keller Mines, Inc., and who always welcomed fossil collectors to his pits.

Occurrence.—34 specimens total, some questionable; Columbiana unit: 1 specimen from loc. Mg-6 (Murphy's loc. 9); Putnam Hill unit: 21 specimens from loc. Ms-3, 3 specimens from loc. Vel-15, 2 specimens from loc. Mg-4, 1 specimen each from locs. Mc-1, Mc-3, Td-4, and Ty-3; Washingtonville unit: 3 questionable specimens from loc. CAr-2.

Repository.—Holotype, OSU 29138; paratypes, OSU 29139 to 29146, 29148, 29155 to 29157; OSU 18729 (doubtful specimens); hypotype, USNM 161420; plus many unnumbered fragmental specimens.

Domatoceras shepherdi Sturgeon, 1946
Pl. 1-28, figs. 5-7; pl. 1-29, fig. 1

Domatoceras shepherdi Sturgeon, 1946, p. 31-32, pl. 7, figs. 1, 2.
Domatoceras williamsi Hansman, 1958, p. 88 (in part).

Diagnosis.—Relatively large *Domatoceras* characterized by a rapidly expanding subtrapezoidal whorl section, a mature high dorsoventral diameter, and a relatively narrow concave venter.

Material.—The original description of this species was based on four specimens from the Columbiana and Washingtonville units. Of those specimens, only the holotype (OSU 18728) and one paratype (OSU 19541) are now available; in addition, there are two more recently collected hypotypes (OSU 28901A and B) from the Washingtonville unit. The holotype is a large, shell-bearing, slightly distorted and compressed conch in which the umbilicus on the right side is covered by matrix. It is incomplete at both the apicad and adoral extremities and has approximately one- and-a-fourth whorls preserved. Hypotype OSU 28901A consists of about one-fourth of a test-covered immature whorl, which is very little distorted; the other hypotype (OSU 28901B) consists of less than one-fourth whorl and is smaller and even more immature than the other hypotype. The measurements and ratios in table 1-15 were determined on the holotype and the two hypotypes.

Description.—Conch large, consisting of approximately three whorls, tarphyceraconic, discoidal; umbilicus rather shallow, gradate, and perforate; perforation subelliptical and about 4 mm long and 2 mm wide in available paratype, not preserved in holotype; outer portion of mature whorl very high and much compressed, especially ventrad; earliest preserved stages nearly circular in cross section, second

TABLE 1-15.—*Conch measurements and ratios of* Domatoceras shepherdi

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W
OSU 18728 (holotype)	140[1]	50[1]	56[2]	55	0.39[1]	1.02[1]
OSU 28901A (hypotype)			51.3	49.5		1.01
OSU 28901A (hypotype)			22.6	25.2		0.90

[1] Approximate measurement.
[2] Estimated measurement.

whorl noticeably compressed with flattening of lateral and umbilical walls and lengthening of dorsoventral diameter; later whorls characterized by rapid increase in height and lateral compression; hypotypes estimated to have occupied positions corresponding to a comparable position from one-third to one-half whorl apicad from adoral end of holotype for the larger one (OSU 28901A) and approximately one whorl distant from apicad end for the smaller one (OSU 28901B); hypotype whorl sections subtrapezoidal in outline, smaller hypotype having a nearly flat venter bordered by weakly nodose ventrolateral carinae, and larger hypotype having a deeply concave venter bordered by nodose carinae; flattened but slightly sigmoidal flanks somewhat concave above ventrolateral carinae, especially above nodes of larger hypotype, and more strongly convex toward umbilical shoulders; umbilical walls steep, flattened to even overhanging, and also slightly sigmoidal, larger hypotype having a small convexity below shoulder and a slight concavity above umbilical seam; smaller hypotype having a slight concavity along median zone and convexities at umbilical shoulder and adjacent to umbilical seam; dorsal impressed zone approximately one-third of conch width; ventrolateral shoulders obtuse, angular, carinate, and nodose externally and rounded internally, location of nodes barely discernible internally; umbilical shoulders subangular and almost carinate externally and rounded internally on smaller hypotype, rounded both externally and internally on larger hypotype and holotype; angle at umbilical seam widely obtuse and carinate externally on larger hypotype; orad portion of holotype's outer whorl similar to those of hypotypes but much higher, its cross section being narrow and concave ventrally, but flattened to a shallow sigmoidal surface laterally, especially orad, flanks tumid and rounded over and adjacent to umbilical shoulders and slightly concave above ventrolateral shoulders; umbilical walls of holotype steep and overhanging, narrower than on hypotypes; ventrolateral shoulders abrupt, angular, carinate; nodose umbilical shoulders obtuse, asymmetrically rounded; dorsum impressed. Test on adoral portion of holotype moderately thick, less so on hypotypes, averaging 1 to 2 mm; much thickened in ventrolateral and umbilical shoulders, attaining a thickness of 5 mm in the umbilical shoulders, increased thickness making the corresponding shoulders more rounded and lessening the ventral concavity on internal mold; surface of test ornamented by fine transverse growth lirae forming a sigmoidal pattern on combined dorsolateral and lateral surfaces and indicating a broad, shallow, rounded hyponomic sinus on venter; each ventrolateral shoulder marked externally by a strong, scalloped, ventrad, projecting ridge formed by confluence of a row of more than 30 elongate, compressed, and bluntly terminated nodes. Internal mold marked faintly by subdued replicas of nodes and along the median third of venter by several longitudinal lirae; maximum spacing of septa 7 to 8 mm apart along flanks and venter and much less in dorsal part of whorl; sutures nearly transverse and somewhat sinuous, forming a rounded ventral lobe, a subangular saddle on ventrolateral angulation, a broad rounded lateral lobe, and a rounded saddle across umbilical shoulder and wall; siphuncle apparently small, orthochoanitic, and located about midway between center and venter of whorl.

Remarks.—Domatoceras shepherdi can be readily differentiated from similar species by its rapid vertical expansion to form a very high and compressed subtrapezoidal whorl section having a maximum H/W ratio of approximately 1.0. Another feature is its concave venter bordered by numerous elongate and compressed nodes on continuous carinae outlining a wavy pattern in ventral view. *Stenodomatoceras moorei* (Miller, Dunbar & Condra) is quite similar in expansion and whorl section, but is more involute, has a smaller umbilicus, and apparently has a less concave venter. *Domatoceras williamsi* Miller & Owen is less involute, has a wider umbilicus, is less rapidly expanded dorsoventrally, and has a less concave venter. *Domatoceras umbilicatum* Hyatt is a much larger species that has a less compressed whorl section. *Domatoceras highlandense* (Worthen) is also less rapidly expanded dorsoventrally and lacks nodes on the orad portion of a mature whorl. *Domatoceras shepherdi* is near the borderline between *Domatoceras* and *Stenodomatoceras*. We are retaining it in *Domatoceras* because its maximum H/W ratio is below the minimum for *Stenodomatoceras* and its involution is less than that for *Stenodomatoceras*. The specific name was given to honor George Shepherd, who collected and generously gave us the holotype for study purposes.

Occurrence.—6 specimens total (2 no longer available); Columbiana unit: 2 specimens from loc. Mg-10; 1 specimen from loc. Mg-2; Washingtonville unit: 2 specimens from loc. CAr-2; 1 specimen from loc. Cs-14.

Repository.—Holotype, OSU 18728; paratype, OSU 19541; hypotypes, OSU 28901A, B.

Domatoceras williamsi Miller & Owen, 1934
Pl. 1-24, fig. 1; pl. 1-25, figs. 1, 2

Domatoceras williamsi Miller & Owen, 1934, p. 194-195, 246-250, pl. 16, fig. 4, pl. 17, figs. 1-4, pl. 18, fig. 1; Sturgeon & Miller, 1948, p. 77-78, pl. 18, fig. 1; Unklesbay, 1962, p. 42, pl. 4, fig. 7.

Diagnosis.—Large, discoidal *Domatoceras* having a small involution, a wide, shallow perforate umbilicus, numerous elongate ventrolateral nodes, and large, short, blunt dorsolateral nodes extended across flanks in coarse lateral ribs on outer mature whorl.

Material.—Miller and Owen had more than 20 specimens from Missouri as the basis for their original description; all but one were from Henry County, that one was from Vernon County. They did not select a holotype but designated several specimens, possibly all, as cotypes. We have studied four of their better syntypes, and one of them (SUI 13418), figured in their plate 17, figure 1 (our pl. 1-24, fig. 1), we have chosen as lectotype for the species. The other available syntypes (SUI 13416, 13417, and 13429) and the unobserved polished section (SUI 13419) (Miller and Owen, 1934, pl. 16, fig. 4) we are specifying as paralectotypes. We are uncertain as to the proper designation for Miller and Owen's other specimens, which we have not seen. We also have two Ohio specimens (OSU 19601 and 40786), which we are referring with some confidence to *Domatoceras williamsi*. All available specimens except the lectotype are exfoliated and somewhat incomplete. The testiferous lectotype is preserved only on the left side, and even that side is incomplete orad. Measurements and ratios in table 1-16 were determined upon the several specimens available to us.

Description.—Conch large to very large, slightly involute, tarphyceraconic, discoidal, consisting of approximately three to three-and-a-half whorls; umbilicus wide, shallow, gradate, and perforate, suboval perforation 4 by 6 mm in size; mature whorl section compressed, considerably higher

TABLE 1-16.—*Conch measurements and ratios of* Domatoceras williamsi

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
SUI 13418 (lectotype)	102	47.5	38				0.47
SUI 13416 (paralectotype)	139.7	70	44.3	36.4	0.26	1.21	0.50
SUI 13417 (paralectotype)	73.4	37.8	28.6	24.5	0.33	1.16	0.51
SUI 13429 (paralectotype)	110	57	35.4	30.7	0.28	1.15	0.51
OSU 19601 (hypotype)	152.4	65.3	40.4	35	0.23	1.15	0.42
OSU 40786 (hypotype)	127	64.8					0.51

than wide, irregularly subhexagonal in cross section, venter and flanks nearly flat, the latter convergent ventrad, maximum whorl width at or just below umbilical shoulders; umbilical walls slightly convex and sloping rather strongly inward, dorsum slightly concave, concavity narrower than width of venter; angles at ventrolateral and dorsolateral shoulders and those at umbilical seams obtuse; ventrolateral shoulder subangular, umbilical seam angular, and dorsolateral shoulder abruptly rounded; earliest whorl subcircular in cross section, becoming progressively flattened, first depressed then compressed, with angulations and impressed dorsum. Test variable in thickness, apparently 1 mm or less in venter, much thicker in ventrolateral shoulders, flanks, and umbilical shoulders, attaining a thickness of 3.5 mm in umbilical shoulders and a greater maximum thickness in dorsolateral nodes and lateral ribs; surface ornament of numerous fine growth lines tracing an outline of a deep U-shaped hyponomic sinus on venter, a lateral sigmoidal pattern with broad, shallow ventral salients and similar dorsal sinuses, and nearly straight courses across umbilical walls; outer whorl of large mature specimens having a row of blunt, rounded, elongate, more or less confluent nodes and on adoral portion a row of low, wide, rounded nodes on umbilical shoulders elongated transversely into lateral ribs; both sets of nodes and lateral ribs formed by thickening of test. Internal mold smooth and nearly even except for sutures and an unobtrusive midventral line indicating a small conchal furrow. Septa nearly transverse, closely spaced, 4 to $4\frac{1}{2}$ in a distance equal to whorl height; mature sutures having broad to very broad, shallow, and rounded ventral, lateral, and dorsal lobes and a subangular saddle at each ventrolateral shoulder and each umbilical seam (fig. 1-8B); siphuncle small, ventrad, circular in cross section, orthochoanitic; septal necks short and straight (approximately one-eighth of a cameral length) and connecting rings cylindrical.

Remarks.—The dorsolateral nodes and lateral ribs are distinctive for shell-bearing representatives of this species, but their absence on internal molds makes comparison difficult with other widely umbilicate species based on exfoliated specimens. We were dubious that the umbilical nodes and lateral ribs did not show on the internal mold, until we temporarily removed a portion of the test from those areas on the lectotype. Miller and Owen compared their specimens with descriptions and figures of *Domatoceras mosquense* (Tzwetaev), *D. sculptile* (Girty), and *D. umbilicatum* Hyatt but were unable to decide if any or all are conspecific. We believe that *D. williamsi* is probably a valid species. Further comparison is made under the remarks in the description of *D. oreskovichi* Sturgeon, Windle, Mapes & Hoare.

Occurrence.—7 specimens total; including 2 from Ohio and 4 observed and 1 unobserved type specimens from Missouri; Lower Mercer unit?: 1 specimen from loc. CScl-1; Vanport unit: 1 specimen from loc. Jmi-3; Cherokee Formation: 4 specimens from loc. MO:Hd-1, 1 specimen from loc. MO:Hw-1.

Repository.—Lectotype, SUI 13418; paralectotypes, SUI 13416, 13417, 13419, and 13429; hypotypes, OSU 19601, 19681, 40786.

Domatoceras cf. *D. highlandense* (Worthen *in* Worthen & Meek), 1875

Pl. 1-28, figs. 1-4

Nautilus (Discites) highlandensis Worthen *in* Worthen & Meek, 1875, p. 531, pl. 33, fig. 2.
Stearoceras highlandensis Kummel?, 1953, p. 58.
Domatoceras highlandense? Windle, 1970, p. 74-80, pl. 2, fig. 11, pl. 3, figs. 1-7.

Diagnosis.—*Domatoceras* having a wide to moderately wide perforated umbilicus and lacking ventrolateral nodes on mature whorls.

Material.—We have four incomplete Ohio specimens (OSU 29150 to 29153) from the Brush Creek, Cambridge, and Ames units and one questionable specimen (OSU 29154) from the Ames unit to compare with Worthen's species. Also available to us were two incomplete specimens (CMNH 3985 and 3986) from the Woods Run (Portersville) unit of western Pennsylvania. Four specimens (OSU 29150 and 29151 and CMNH 3985 and 3986) are more or less testiferous and are also much distorted and mashed. Two other specimens (OSU 29152 and 29153) are largely exfoliated; one specimen (OSU 29152) consists of short lengths of the body chamber and of the phragmocone. The questionable specimen (OSU 29154) is embedded in matrix on its right side and has been polished to show septa and the body chamber. The data in table 1-17 were determined upon the specimens listed. The two sets of measurements and ratios for OSU 29152 were determined at two and at two-and-a-half volutions from the apex. Worthen's figure of the type specimen shows a conch diameter of 90 mm, an umbilical diameter of 35 mm, a whorl height of 30 mm, and a U/D ratio of approximately 0.40.

Description.—Conch large, consisting of approximately three volutions with at least one-third of ultimate whorl being body chamber, tarphyceraconic, intermediate between discoidal and subdiscoidal; umbilicus moderately wide to wide, gradate, and perforate; mature whorl section compressed, subquadrate; venter flattened, apparently slightly concave externally and weakly convex internally; flanks flattened, slightly convex near umbilical shoulders, convergent ventrad, maximum width at or just below dorsolateral shoulders; umbilical walls flattened, steeply sloping inward toward center of conch, overhanging with a heavy keel of thickened shell near orad extremity on specimen OSU 29151;

TABLE 1-17.—*Conch measurements and ratios of* Domatoceras *cf.* D. highlandense

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
OSU 29150[1] (hypotype)	120	48					0.40
OSU 29151 (hypotype)	100	40	35	30±	0.30±	1.16±	0.40
OSU 29152[2] (hypotype)	40	19	18	15	0.38	1.20	0.48
OSU 29152[2] (hypotype)	56	24	22	19	0.33	1.15	0.43
OSU 29153 (hypotype)			29	26		1.11	
CMNH 3985 (hypotype)			35	25±		1.40	
CMNH 3986 (hypotype)	85	30±	35	24±	0.30	1.45±	0.35

[1] Specimen mashed.
[2] Two measurements on same specimen.

internal angles at ventrolateral and umbilical shoulders and at umbilical seams obtuse, ventrolateral shoulder more narrowly rounded and umbilical seams raised into a low rounded ridge; external angles more sharply rounded; dorsum slightly to moderately impressed, approximately 2 mm at a whorl height of 20 mm and a width of 26 mm (OSU 29153), and a depth equal to one-tenth of whorl height at end of two volutions (OSU 29152); initial whorl section subcircular and having straight sutures and perforate umbilicus; at end of two volutions whorl section subquadrate to unevenly subhexagonal, becoming more compressed with additional growth. Test thick, variable in thickness, thicker in ventrolateral and dorsolateral shoulders, attaining a maximum thickness of 5 mm in dorsolateral keel and 3 mm in flanks, thinner in venter and umbilical walls; surface ornament consisting of narrow, almost acuminate growth lirae separated by wider rounded troughs outlining a deep linguloid hyponomic sinus, a low lateral salient, and a shallow dorsal re-entrant (CMNH 3985 and 3986). Only sutures visible on internal mold; mature suture pattern consisting of a shallow, rounded ventral lobe, asymmetrical to sigmoidal, broad, shallow rounded lateral lobes, rounded moderately shallow dorsal lobe, narrowly rounded ventrolateral saddles, and a very low, broadly rounded saddle across each umbilical wall; septa nearly transverse except those on specimen OSU 29153, which are oblique, and having an extreme dorsal extension orad; septa more convex dorsoventrally than transversely; siphuncular structure not exposed, subcentral to definitely ventrad, presumably orthochoanitic.

Remarks.—As far as can be determined from Worthen's illustration and description of *Domatoceras highlandense* from the McLeansboro Group of Illinois, our specimens seem to compare very closely with his species. Approximate correlation of the Conemaugh and McLeansboro Groups may be another favorable basis for comparison of our specimens with Worthen's species. Two factors mitigate against positive identification: the whereabouts of the holotype or any authentic specimens of *D. highlandense* are unknown, and Worthen's description is brief and inadequate for current methods of study. There is some variation among our specimens and they may not all belong to the same species. One specimen (OSU 29153) from the Ames unit apparently had a much thinner test and a more centrally located siphuncle than certain other specimens (OSU 29151 and 29152 and CMNH 3985 and 3986). The oblique septa of OSU 29153 have already been mentioned. Until Worthen's type specimen(s) or reliable topotype material is available, reliable comparisons cannot be made between *D. highlandense* and our specimens. *Domatoceras umbilicatum* Hyatt appears to resemble *D. highlandense* but is a much larger species and has more compressed whorls. Other American species of *Domatoceras* are either based on immature specimens or have noded ventrolateral shoulders. Our questionable polished specimen (OSU 29154) may not even be a *Domatoceras*.

Occurrence.—7 specimens total, 1 or more questionable; Ames unit: 1 specimen each from locs. Aa-58, JEst-1, and MUu-2; Brush Creek unit: 1 specimen from loc. Aa-41; Cambridge unit: 1 specimen from loc. Gwe-1; Woods Run (Portersville) unit: 1 specimen each from locs. PA:Apl-1 and PA:Wa-1.

Repository.—OSU 29150 to 29154, CMNH 3985, 3986.

Domatoceras spp.

Pl. 1-24, figs. 4-8

Diagnosis.—Medium-sized to large, moderately involute *Domatoceras* having mature and early mature compressed subtrapezoidal whorls and rather strong convergence ventrad; venter moderately concave, bordered by a keel on each ventrolateral shoulder, keels weakly noded on mature whorls.

Material.—We have one specimen (OSU 29158) consisting of one-fourth of a shell-covered volution from the Brush Creek unit and several fragments (OSU 29159) representing one or more individuals from the Ames unit. Only two whorl measurements and one ratio can be ascertained from these specimens; these are given in table 1-18.

Description.—Conch medium sized to large, moderately involute, tarphyceraconic; umbilicus deep, steep walled, and gradate; mature whorl section subtrapezoidal; venter concave both outside and inside of test, more so externally, bordered on each ventrolateral margin by a sharply rounded keel; keel weakly nodose on larger specimen; flanks wide, flattened, slightly concave above ventrolateral shoulders and slightly more convex toward umbilical shoulders; maximum whorl width below umbilical shoulders on both specimens; umbilical walls convex along middle area with slight but definite depressed linear zones below bulging umbilical shoulder and above inward extension of shell at umbilical seam of larger specimen (OSU 29158), similar on smaller

TABLE 1-18.—*Conch measurements and ratios of* Domatoceras *spp.*

Specimen	H (mm)	W (mm)	H/W
OSU 29158	35.8	33	1.08
OSU 29159	24	22.8	1.05

specimen (OSU 29159) except lacking linear depression below umbilical shoulders; dorsum moderately impressed (measurements given in table 1-18); ventrolateral shoulders acute both externally and internally on smaller specimen, obtuse internally on larger one; umbilical shoulders obtuse and rounded, more narrowly rounded externally; angle at umbilical seams obtuse internally with shell covering elevated into a rounded acuminate ridge. Test thin, less than 1 mm thick on venter and flanks, thickening to more than 1 mm in ventrolateral and umbilical shoulders; ventrolateral shoulder rather narrowly elevated into a rounded acuminate keel and umbilical shoulder broadly raised into a broadly rounded indistinct ridge; surface ornament on smaller specimen consisting of equal-sized growth lirae and striae outlining a very wide, moderately deep, broadly rounded hyponomic sinus, an asymmetrical sigmoidal course with a rather strong rounded orad convexity above ventrolateral shoulders, a broader and shallower concavity orad toward umbilical shoulders, and a nearly straight course across umbilical walls; venter of smaller specimen having numerous slightly unequal longitudinal lines practically the same size as growth lines, forming a reticulate pattern with growth lines, only traces of reticulate pattern on weathered surface of larger specimen; ventrolateral keels even crested on smaller specimen, keels less prominent but with slender, elongate, confluent nodes on apicad half of larger specimen, both nodes and keel disappearing on orad portion. Septa extended much farther orad dorsally, strongly convex dorsoventrally, maximum convexity between center and dorsum, much less transverse convexity; suture pattern consisting of a shallow rounded ventral lobe (very shallow on larger specimen), very broadly rounded, slightly asymmetrical lateral lobes, a deep rounded dorsal lobe, narrowly and sharply rounded ventrolateral saddles, and weak but definite saddles at umbilical shoulders and seams; siphuncle elliptical in outline at passage through septa, higher than wide, located very definitely ventrad, about one-third of distance above venter along surface of a septum.

Remarks.—As far as can be ascertained, these specimens are characterized by thin-shelled conchs having subtrapezoidal mature whorls that are compressed, strongly convergent ventrally, and moderately involute. The concave venter is bordered by a ventrolateral keel surmounted by inconspicuous, elongate, thin, confluent nodes on the apicad portion of mature? whorl(s). Other distinguishing features are a reticulate ventral ornament, a very wide hyponomic sinus occupying almost the full width of the venter (in fact, this is one of the widest ventral sinuses observed among our various species), and the siphuncle located well toward the venter. These specimens suggest *Domatoceras sculptile* (Girty) and *Stenodomatoceras gardi* (Murphy). Girty's species, however, has a convex venter without pronounced bordering keels and with a more V-shaped hyponomic sinus. *Stenodomatoceras gardi* has a similar concave keel-bordered venter showing a very wide, rounded, shallow sinus and a reticulate ornament pattern, but has a more compressed and higher mature whorl section, is more involute, and has a smaller umbilicus. We are retaining our two specimens under consideration in *Domatoceras*, as their H/W ratios are more than 10 percent less than the 1.20 H/W ratio arbitrarily recognized as a minimum for mature *Stenodomatoceras*.

Occurrence.—2+ specimens total, plus several fragments; Ames unit: 1 specimen plus 3 smaller fragments from loc. MUu-2; Brush Creek unit: 1 specimen from loc. Cma-9.

Repository.—OSU 29158, 29159.

Genus *Stenodomatoceras* Ruzhencev & Shimansky, 1954

Type species: *Domatoceras moorei* Miller, Dunbar & Condra, 1933; OD

Grypoceras Kummel, 1953, p. 48-55 (in part).
Stenopoceras Kummel, 1953, p. 57-58; Ruzhencev & others, 1962, p. 134.
Stenodomatoceras Ruzhencev & Shimansky, 1954, p. 94; Windle, 1970, p. 80-81.
Domatoceras Kummel, 1964, p. K433.

Diagnosis.—Grypoceratids similar to *Domatoceras* but possessing rather strongly compressed and more involute mature subtrapezoidal whorls.

Description.—Conch medium sized to large, moderately involute, subdiscoidal to discoidal, possessing rather strongly compressed mature subtrapezoidal whorl sections, W/D ratios 0.30 to 0.40 and H/W ratios approximately 1.20 or more; ventrolateral shoulders carinate and commonly nodose; concave venter on ultimate whorl; otherwise similar to *Domatoceras*.

Remarks.—*Stenodomatoceras* is intermediate and apparently a direct link between *Domatoceras* Hyatt and *Stenopoceras* Hyatt; as shown in the synonymy above, not all authorities accept it as a separate genus. In 1953 Kummel (p. 51, 57) recognized that *Domatoceras kleihegei* Miller, Lane & Unklesbay and *D. moorei* Miller, Dunbar & Condra are transitional forms between *Domatoceras* and *Stenopoceras*. Ruzhencev and Shimansky (1954, p. 94) included both species in *Stenodomatoceras*, recognizing that these species differed significantly from *Domatoceras*. The type species of *Domatoceras*, *D. umbilicatum* Hyatt, differs from *D. kleihegei* and *D. moorei* in possessing lower and wider mature whorl sections, ventrolateral shoulders without a trace of nodes on the internal mold, a larger umbilical diameter, and a U/D ratio of 0.35 compared to 0.16 to 0.17 for *D. kleihegei* and *D. moorei*. Ruzhencev and others (1962, p. 134), however, did place *Stenodomatoceras* in the synonymy of *Stenopoceras*. Kummel (1953, p. 54) considered *Domatoceras* as a subgenus of *Grypoceras* Hyatt and noted several differences between them, including deeper lobes, a dorsal annular lobe, and greater involution for *Grypoceras*. Later, Kummel (1964, p. K432-K433, K436) listed both these genera as well as *Stenopoceras* as separate genera under the family Grypoceratidae, but suppressed *Stenodomatoceras* as a synonym of *Domatoceras*. Even though we had considerable uncertainty in the generic assignment for two species under consideration, we believe that *Stenodomatoceras* warrants recognition for intermediate forms between *Domatoceras* and *Stenopoceras*. We are including not only *Domatoceras kleihegei* Miller, Lane & Unklesbay and *D. moorei* Miller, Dunbar & Condra, but also *D. gardi* Murphy. *Domatoceras shepherdi* Sturgeon is very close to *Stenodomatoceras* but has a wider umbilicus, a more concave venter, and lower and less involute mature whorls. The genus presently is known only from the United States. Its stratigraphic occurrences are in the lower portion of the Missourian Series (Kansas City Group) of Kansas and Missouri and in the Conemaugh Group (Brush Creek unit) of eastern Ohio and western Pennsylvania.

Geologic range.—Middle-Upper Pennsylvanian.

Stenodomatoceras gardi (Murphy), 1970

Pl. 1-30, figs. 1-8

Domatoceras spp. Miller & Unklesbay, 1942b, p. 144, pl. 5, figs. 2-4.
Domatoceras gardi Murphy, 1970, p. 201-203, pl. 36, figs. 3-6.
Stenodomatoceras n. sp. Windle, 1970, p. 81-85, pl. 5, figs. 5-8; pl. 6, figs. 4-13.

Diagnosis.—Stenodomatoceras characterized by a moderately compressed conch, keeled ventrolateral shoulders with longitudinally elongate nodes, and concave venter on mature whorl.

Material.—There are approximately 50 specimens and recognizable fragments from the Brush Creek unit and possibly one from the Cambridge unit in our collection. Murphy had 38 good specimens and numerous fragments from the Brush Creek unit and a doubtful specimen from the Washingtonville unit. Our largest specimens attain a maximum conch diameter of more than 100 mm, and Murphy reported a maximum diameter of 110 mm and three- and-a-half whorls for his largest specimens. The measurements and ratios in table 1-19 are based upon several of our better topotypes. Table 1-20 shows changes in whorl and conch development at various stages of growth in several topotypes.

Description.—Conch tarphyceraconic in initial whorl, nautiliconic in subsequent volutions, discoidal; umbilicus narrow, steep walled, gradate, and perforate; perforation bluntly raindrop shaped, approximately 6 mm in maximum diameter; mature whorl section compressed, subtrapezoidal in outline, and convergent ventrad, maximum width a short distance below umbilical shoulders, passing through an evolutionary series (see table 1-20), whorls initially rounded and transverse; umbilical shoulders developing at one-half whorl growth stage and ventrolateral angulations at about one whorl on internal mold, these undoubtedly visible at earlier stages on exterior of test; whorl outline remaining transverse until a conch diameter of 40 to 50 mm attained; dorsal impressed zone initiated at an approximate conch diameter of 30 mm or earlier, developed into an involution 12 mm deep and 16 mm wide at a conch diameter of 77 mm; venter flattened, bordered on each side by an acutely angular keel, with a resultant concavity throughout most of its length, convex and rounded in earliest growth stages and more strongly flattened on mature portions of adult conchs; each ventrolateral shoulder with small, elongate, continuous nodes between conch diameters of 55 and 70 mm and whorl heights of 25 to 30 mm; flanks flattened and tapering ventrad and gently convex dorsad, passing over abruptly rounded umbilical shoulders onto steep, slightly convex, and even overhanging umbilical walls, umbilical shoulders less abrupt orad on mature specimens; dorsal impression slightly less than half a whorl wide and progressively deeper with growth. Test variable in thickness, ranging from less than 1 mm to 2 mm or more, thickest in umbilical shoulders and walls; surface marked by transverse striae separated on small to medium-sized specimens by broad rounded lirae; striae forming a deep, broadly rounded ventral sinus, a sigmoidal pattern with a broadly rounded orad extension dorsally, and a nearly straight course across umbilical walls; longitudinal lirae also present on venter and portions of flanks, locally forming a reticulate pattern with growth lines visible on better preserved individuals. Internal mold marked by sutures and an inconspicuous midventral ridge, indicating a shallow conchal furrow; septa moderately convex apicad, nearly transverse to whorl axis although extended a little orad dorsally, spacing varying from 3 to 7 mm on flanks and venter of larger specimens; siphuncle 2.5 mm in diameter and located one-third of whorl distance

TABLE 1-19.—*Conch measurements and ratios of* Stenodomatoceras gardi

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
OSU 28944 (topotype)	70.9[1]	18.7					0.26[1]
OSU 28945 (topotype)	77	21	43	35	0.45	1.22	0.27
OSU 28946 (topotype)	93	21.5[2]	45.5	37[2]	0.40[2]	1.23[2]	0.23[2]
OSU 28947 (topotype)	54	15	29	25	0.46	1.15	0.28
OSU 28948 (topotype)	41.5	12.5[2]	20	21[2]	0.53[2]	0.95[2]	0.30[2]
OSU 28949 (topotype)	30.3	9.7	13	12	0.45	1.08	0.32

[1] Measurement approximate because of nature of preservation.
[2] Estimated measurements.

TABLE 1-20.—*Conch measurements and ratios showing changes in whorl and conch development of various stages of growth in* Stenodomatoceras gardi

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	V (mm)	W/D	H/W	U/D	Remarks
OSU 28965	11±		5	6.5		0.60	0.75		first half volution
OSU 28949	17	8	6.5	8.7	5	0.53	0.75	0.47	one complete volution
OSU 28951	30	10	15	14±	7	0.47	1.08	0.33	one-and-one-half volutions
OSU 28967	43	13	20	23	10	0.53	0.87	0.30	one-and-one-half volutions
OSU 28961	54	17	27	25	12	0.46	1.10	0.31	two complete volutions
OSU 28947	54	15	29	25	11	0.46	1.15	0.28	two complete volutions
OSU 28962[1]			32	32	15		1.00		ultimate septum (mature?)
OSU 28962[1]			40	40	20		1.00		at adoral margin
OSU 28945	77	21	43	35	17	0.45	1.22	0.27	mature whorl

[1] Measurement approximate because of nature of preservation.

above venter, other details unknown; sutures having a rounded, moderately deep ventral lobe (not developed until about one-and-one-half whorl stage), an acutely angular ventrolateral saddle (more acute on mature portions and subangular to rounded in earlier stages), a broad, shallow lateral lobe, a low, narrow, and rather indistinct saddle on umbilical wall, and a shallow dorsal lobe.

Remarks.—Stenodomatoceras gardi is similar to two Midcontinent species, S. kleihegei (Miller, Lane & Unklesbay) from the Winterset Limestone in Kansas City, Missouri, and *S. moorei* (Miller, Dunbar & Condra) from the Corbin City Limestone in Cherryvale and Independence, Kansas. We have observed the type specimens of both of these species and find that they differ from each other in amount of involution and development of nodes on mature whorl. *Stenodomatoceras moorei* is also more discoidal and has a narrower venter. These two Midcontinent species are more alike than they are similar to *S. gardi*; H/W and U/D ratios for *S. gardi* indicate that it is closer to *Domatoceras* than are the Midcontinent species.

Occurrence.—46 specimens total, 2 questionable; Brush Creek unit: 44 specimens from loc. Cma-3, 1 questionable specimen from loc. Aa-41; Cambridge unit: 1 questionable specimen from loc. Ls-1.

Repository.—Topotypes, OSU 28944 to 28949, 28951 to 28953, 28961 to 28965, 28967, 28968, 29259; questionable hypotypes, OSU 28966, 28970.

Genus *Stenopoceras* Hyatt, 1893

Type species: *Phacoceras dumblei* Hyatt, 1891; OD

Stenopoceras Hyatt, 1893, p. 446-447; Miller, Dunbar & Condra, 1933, p. 76, 222-223; Miller & Youngquist, 1949, p. 70-71, figs. 20A, B; Kummel, 1953, p. 57-58; 1964, p. K436, figs. 314, 5a, b; Ruzhencev & Shimansky, 1954, p. 94; Ruzhencev & others, 1962, p. 134; Windle, 1970, p. 85-87.

Diagnosis.—Grypoceratids possessing a small umbilicus and strongly compressed and deeply involute whorls with narrow venters.

Description.—Conch medium sized to large, rapidly expanded, deeply involute, nautiliconic, subdiscoidal to discoidal; umbilicus indistinctly perforate during early growth stages and imperforate or nearly so at maturity; whorls high, narrow, compressed, and flat sided; venter narrow and flat or slightly concave; angular ventrolateral shoulders and broadly rounded umbilical shoulders; growth lines outlining a deep ventral sinus, a broad ventrolateral salient, and lateral rounded orad concavity; suture pattern having rounded ventral and dorsolateral saddles, rounded lateral and umbilical-seam lobes, and V-shaped dorsal lobe; siphuncle small, ventrad.

Remarks.—As previously noted, the grypoceratid genera *Domatoceras*, *Stenodomatoceras*, and *Stenopoceras* represent an evolutionary series culminating in the latter genus. *Domatoceras* appeared in the lower Middle Pennsylvanian (Desmoinesian) of the Midcontinent region. The earliest representatives are similar to the type species, *D. umbilicatum* Hyatt, and are characterized by a large, wide umbilicus, U/D ratios equaling 0.40 to 0.55 (using maximum umbilical diameter), shallow involution (depth of impressed zone less than 0.10 of whorl height), and venter width normally exceeding 0.50 of maximum whorl width. *Domatoceras shepherdi* Sturgeon, a middle Allegheny (Desmoinesian) species, is the earliest to show a definite increase in involution (U/D ratio of 0.36) and an increase in whorl compression and height (H/W ratio up to 1.00+). By early Missourian time, several species had developed conch forms similar to that of *Stenopoceras*. These transitional species are assigned to the genus *Stenodomatoceras* and include *S. gardi* (Murphy), *S. kleihegei* (Miller, Lane & Unklesbay) and *S. moorei* (Miller, Dunbar & Condra). *Stenodomatoceras* species are distinguished by a moderately narrow umbilicus having a U/D ratio of approximately 0.25, deep involution of the whorls and the impressed zone equaling about 0.25 of the whorl height at maturity, and the venter narrower than those of typical *Domatoceras*, the width generally less than 0.50 of maximum whorl width. Pennsylvanian representatives are known from the Conemaugh of eastern Ohio (Miller and Unklesbay, 1947, p. 323-324), the Casper Formation of Wyoming (Miller and Thomas, 1936, p. 722, 734-736), and the western part of the former Soviet Union (Trautschold, 1874). Permian examples are known from Kansas, New Mexico, and Texas (Miller and Youngquist, 1949, p. 71-80).

Geologic range.—Upper Pennsylvanian-Lower Permian.

Stenopoceras smithi Miller & Unklesbay, 1947
Pl. 1-46, fig. 6

Stenopoceras smithi Miller & Unklesbay, 1947, p. 323-324, pl. 2, figs. 1, 2; fig. 1; Windle, 1970, p. 87-90 (in part), pl. 7, figs. 1, 2.

Diagnosis.—A species of *Stenopoceras* differentiated by closed or nearly closed infundibulum of mature umbilicus, a moderately narrow venter (width approximately 0.40 of maximum whorl width), and a narrowly rounded dorsolateral saddle.

Material.—Miller and Unklesbay based their original description of *Stenopoceras smithi* on the only two available specimens, which are imperfectly preserved molds (SUI 8174A and B); they were originally designated as syntypes. The larger one, SUI 8174A, designated the lectotype by Windle (1970, p. 88), has a preserved maximum diameter of approximately 120 mm; the other one, SUI 8174B, designated a paralectotype by Windle, is a less complete and smaller individual (pl. 1-46, fig. 6). Windle's designations were never published, so we hereby validate his designations.

Description.—Conch large, strongly involute, subdiscoidal, nautiliconic; inconspicuous closed or nearly closed mature umbilicus, U/D ratio generally less than 0.20; high compressed mature whorl, W/D ratio less than 0.40 at maturity; narrow concave venter bordered by narrowly rounded carina on each subangular ventrolateral shoulder, sigmoidal flanks having a concavity above the ventrolateral shoulders and a broadly rounded convexity above and over umbilical shoulders; maximum whorl width below umbilical shoulders (fig. 1-9); body chamber apparently occupied slightly more than one-half volution. Test apparently thin; surface bearing numerous fine growth lines showing a shallow, broad, rounded ventral sinus; further details not preserved. Septa and sutures visible only on flanks and venter; septa nearly transverse to whorl axis; sutures displaying a rather shallow, broadly rounded ventral lobe, small subangular ventrolateral saddles, broadly rounded lateral lobes, a high subangular dorsolateral saddle, and fairly deep lobe apparently centered on umbilical seams; dorsal portion of suture

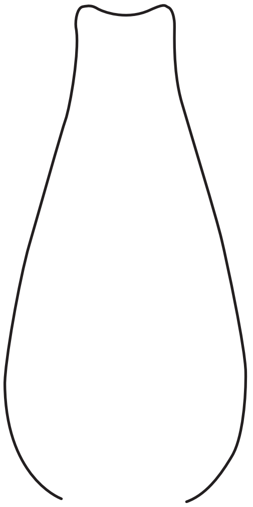

FIGURE 1-9.—*Stenopoceras smithi* Miller & Unklesbay. Diagrammatic cross section based on the adoral portion of the phragmocone of a paralectotype, X1$^1/_4$; Ames unit, loc. At-67; SUI 8174B. After Miller and Unklesbay (1947).

pattern and entire siphuncle unknown.

Remarks.—*Stenopoceras smithi* does not closely resemble any other congeneric form except *S. abundum* Miller & Thomas from the Casper Formation of Wyoming. The Wyoming species differs from *S. smithi* by possession of more broadly rounded dorsolateral saddles, a significantly narrower venter (width less than 0.40 of maximum whorl width), and less acute ventrolateral shoulders.

Occurrence.—2 specimens; Ames unit: loc. At-67.

Repository.—Lectotype, SUI 8174A; paralectotype, SUI 8174B.

Genus *Solenochilus* Meek & Worthen, 1870

Type species: *Nautilus (Cryptoceras) springeri*
White & St. John, 1868; OD

Solenochilus Meek & Worthen, 1870, p. 47-48; Miller, Dunbar & Condra, 1933, p. 228-232; Miller & Youngquist, 1949, p. 131-132, fig. 38; Kummel, 1964, p. K441, figs. 318, 2a, b, 319, 320, 1, 321; Gordon, 1964, p. 152-153; Mikesh & Glenister, 1968, p. 271-273, figs. 1A, B; Windle, 1970, p. 90-92.
Asymptoceras Hyatt, 1884, p. 296-297; 1891, p. 345-346.
Solenocheilus Hyatt, 1893, p. 460-461; 1900, p. 525; 1913, p. 606.

Diagnosis.—Large, loosely coiled, rapidly expanded, subglobular nautilicones; marginal, ventral, dorsally cyrtochoanitic siphuncle; pair of prominent dorsolateral spines in adult stage.

Description.—Mikesh and Glenister's (1968, p. 271-273) description of the genus *Solenochilus* is quoted in full here:

> Loosely coiled, rapidly expanded nautilicones characterized by development of a pair of conspicuous dorsolateral spines at maturity. Mature conch approximating 100 to 200 mm in diameter, consisting of slightly less than two volutions, and exhibiting a narrowly perforate umbilicus in better known species. Length of body chamber one-third volution. Shell smooth, growth lines form broad deep hyponomic sinus and shallow narrow dorsolateral sinus. Whorl section strongly depressed (height/width of $^1/_2$) to equidimensional; dorsum generally flat, but varying from slightly convex to shallowly impressed; greatest width at mid-height in most species but close to umbilical shoulder in others; venter broadly rounded. Pronounced dorsolateral ridge developed progressively on umbilical shoulder of ultimate half volution, expanded into long hollow dorsolateral spine close to mature aperture. Sutures straight to slightly sinuous. Siphuncle ventral, marginal, with diameter $^1/_{10}$ to $^1/_{20}$ that of corresponding whorl height. Septal necks straight and almost hemichoanitic on ventral margin, recumbent cyrtochoanitic on dorsal side; siphuncular segments strongly expanded at mid-length. Ectosiphuncular sutures delimit characteristic circular area at mid-length of camerae.

Remarks.—Examples of this genus are recognized by their large, rapidly expanded, loosely coiled nautiliconic conchs that have depressed to subequal whorl sections, ventral marginal siphuncles, relatively smooth surfaces, angular dorsolateral shoulders, and, at maturity, a pair of long dorsolateral spines. The lateral spines (pl. 1-38, fig. 1; fig. 1-10), which are the most distinctive feature of this and two other similar-appearing genera, are unfortunately almost always broken away, so that only recently have their form and position been fully understood. The function of the spines is still conjectural. Approximately two dozen species, two of which are tentative, are identified as representatives of the genus *Solenochilus* (Gordon, 1964, p. 152-153). In spite of Mikesh and Glenister's statement (1968, p. 276) that most species of *Solenochilus* are too insufficiently known for adequate specific comparisons, Gordon (1964, p. 152-153) was able to compile a simple but seemingly usable artificial key for at least tentative identification of North American species of the genus. There is no doubt, however, that some physical features of most species are unknown or incompletely known.

Acanthonautilus Foord and *Permonautilus* Kruglov are similar to *Solenochilus* in external appearance. According to Mikesh and Glenister (1968, p. 270), *Acanthonautilus* is a Mississippian genus and an authentic member of the family Solenochilidae, differing from *Solenochilus* in possessing tubular siphuncular segments. The affinities of *Permonautilus* from Upper Permian strata of the former Soviet Union are uncertain. It is not certain that all the syntypes of the type species, *Nautilus cornutus* Golovkinsky, are conspecific. The largest syntype does resemble *Acanthonautilus* and *Solenochilus* in external form. Its siphuncle, however, is unknown and some other specimens identified as *Permonautilus* have subcentral siphuncles; if true for all, the presence of a subcentral siphuncle would place the genus in the family Liroceratidae. Mikesh and Glenister (1968, p. 273) conclude that: "Only detailed study of the siphuncle can clarify the temporal and morphologic relations between *Acanthonautilus*, *Solenochilus*, and *Permonautilus*."

Solenochilus is a widespread Pennsylvanian and Lower Permian genus; representatives are known in Europe and North America and perhaps in Asia and South America. Gordon (1964, p. 152), who included Mississippian species that possibly should be referred to *Acanthonautilus*, listed 24 species, 16 of which are North American, one possibly South American, and the others presumably European. A cursory check of Gordon's list of North American species indicates that at least a dozen are from the Pennsylvanian System and two or more are from the Permian System; specimens

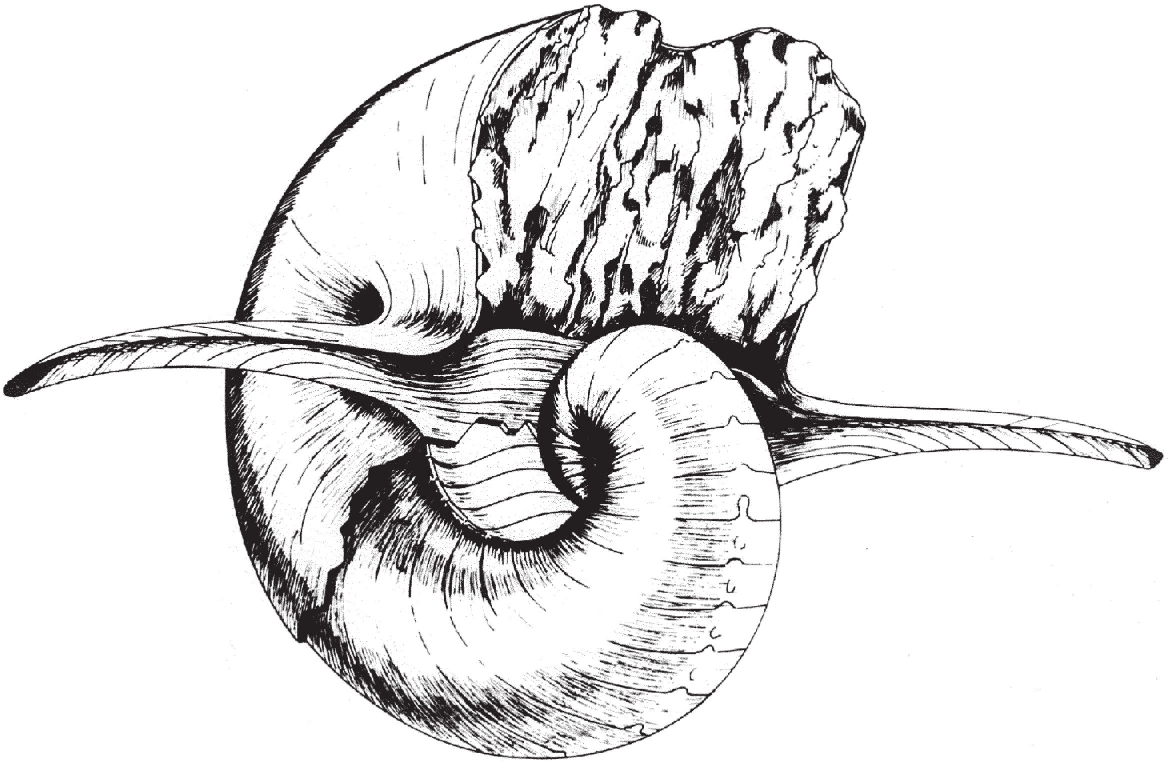

FIGURE 1-10.—*Solenochilus springeri* (White & St. John). Oblique view of a composite specimen based on materials from the Pennsylvanian of Arkansas and Iowa showing the general form of the conch and its lateral spines; approx. X$^3/_5$; Bloyd Formation, Washington County, Arkansas, and Desmoinesian?, Marion County, Iowa. After Furnish and Glenister (1964, fig. 319).

(not including any possibly Mississippian species) have been collected in Arkansas, Iowa, Kansas, Kentucky, Missouri, Nebraska, Ohio, Pennsylvania, Texas, and Wyoming. Five species have previously been definitely identified in Ohio; these include one Pottsville species from the Lowellville (Poverty Run) and Lower Mercer units, two Allegheny species from the Putnam Hill, Vanport, and Columbiana units, and two Conemaugh species from the Brush Creek and Cambridge units. One species has been identified from the Brush Creek and Pine Creek units of western Pennsylvania. We describe nine possible species in this report, but we recognize that one or more of these may prove eventually to be synonyms.

Geologic range.—Pennsylvanian-Lower Permian.

Solenochilus bognari Sturgeon, 1946
Pl. 1-33, figs. 1, 2

Solenochilus bognari Sturgeon, 1937, p. 358; 1946, p. 12, 32-33, pl. 9, figs. 1, 2; fig. 3B.

Diagnosis.—Medium-sized to large solenochilid having a laterally and ventrally rounded equidimensional whorl profile, a strong revolving concave zone ventrad to umbilical shoulders, and a ventral saddle in the suture pattern.

Material.—The holotype is the only known representative of this species; it is an incomplete internal mold consisting of about one-half whorl showing the venter, the left side of 12 camerae of the phragmocone, and a small apical portion of the body chamber. The specimen apparently represents an immature individual, as there is no shortening of the camerae and crowding of the septa adjacent to the body chamber. The conch and whorl measurements in table 1-21 were taken 165 mm apart along the median line of the venter.

Description.—Conch large, subglobose, rapidly expanded orad, nautiliconic; umbilicus narrow, steep walled, and deep; whorl section equidimensional, becoming slightly depressed toward adoral end; venter broadly rounded, crossing indistinct broadly rounded ventrolateral zones and merging with flattened lower three-fifths of sides, dorsal two-fifths of sides slightly concave, especially near obtuse, abruptly subangular, elevated umbilical shoulder; toward apicad end flattened ventral portion of sides becoming more rounded

TABLE 1-21.—*Conch measurements and ratios of* Solenochilus bognari

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
OSU 18730[1] (holotype)			40	40		1.00	
OSU 18730[2] (holotype)	150	25	85	94	0.63	0.90	0.17

[1] Measured near apicad end of conch.
[2] Measured near orad end of conch.

and convex, maximum whorl width between boundary separating the two areas of flanks, ventral portion of sides converging somewhat toward venter, and slightly concave dorsal portion much more strongly convergent toward dorsum; umbilical wall steep, nearly vertical, weakly convex, merging without a sharp separation with moderately deep impressed dorsal zone (fig. 1-11A). Internal mold smooth except for sutures and siphuncle; septal spacing variable, as much as 20 mm along venter but only 5 mm at umbilical shoulder, ratio of maximum width of conch to maximum septal spacing about 4.5 to 1; sutures nearly transverse to conchal axis, slightly sinuous, and forming a low but distinct median ventral saddle flanked on either side by a similar lobe, a broad shallow saddle on flattened part of sides, another shallow and slightly asymmetrical lobe on the concave part of sides, a subangular saddle at umbilical shoulder, and a faint lobe on umbilical wall; remainder of suture obliterated before reaching umbilical seam; siphuncle ventral, marginal, and in contact or nearly so with ventral wall; septal necks nearly straight and cylindrical, extending about 5 mm apicad from septum; connecting rings expanded and either pyriform or cylindrical, but apparently pyriform, smaller end toward apex; this appearance probably largely or entirely due to manner of breaking of matrix away from ventrolateral margins of connecting rings; 12 mm maximum exposure of connecting rings across camerae.

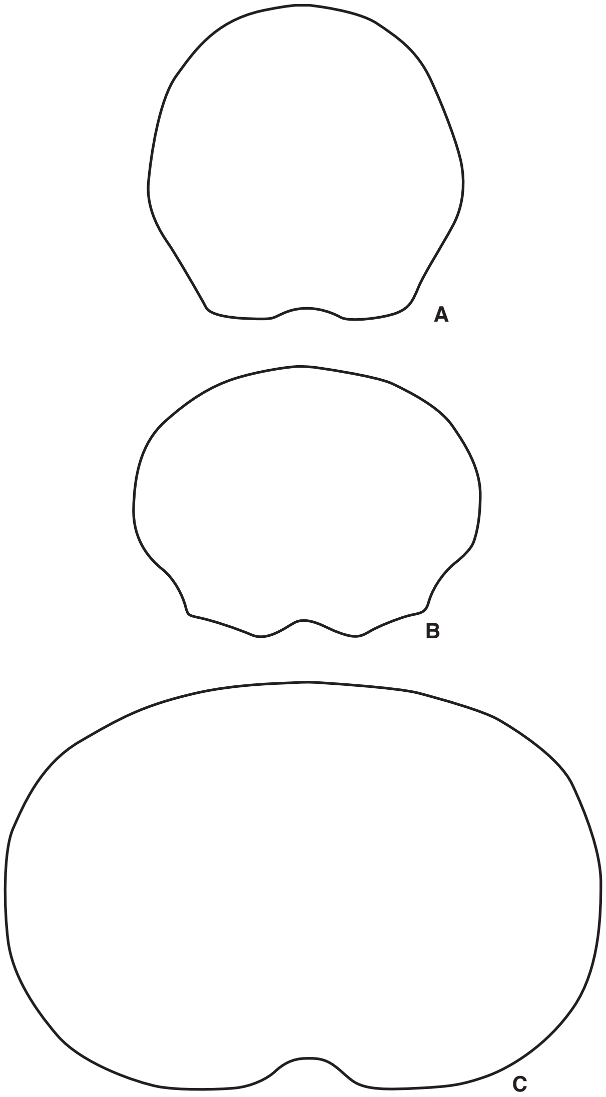

FIGURE 1-11.—Diagrammatic cross sections of ultimate whorls of three species of *Solenochilus* showing variations in outlines. Magnifications approximate.

- **A**, *Solenochilus bognari* Sturgeon. Cross section of holotype; X$^{1}/_{2}$; Vanport unit, loc. Tl-1; OSU 18730 (also see pl. 1-33, figs. 1, 2). After Sturgeon (1946).
- **B**, *Solenochilus greenensis* Sturgeon. Cross section of a syntype; X$^{1}/_{2}$; Columbiana unit, loc. Mg-7; OSU 18731 (also see pl. 1-34, fig. 3). After Sturgeon (1946).
- **C**, *Solenochilus* sp. Cross section of only specimen; X $^{7}/_{10}$; Washingtonville unit, loc. MUmu-1; OSU 28860 (also see pl. 1-39, fig. 1).

Remarks.—The distinctive features of *Solenochilus bognari* are its equidimensional whorl section with maximum width ventrad to umbilical shoulders, a strong revolving concave zone just ventrad to each umbilical shoulder, and a median ventral saddle on each suture. *Solenochilus peculiare* Miller & Owen has a median ventral saddle but has a depressed whorl section. *Solenochilus capax* (Meek & Worthen), *S. greenensis* Sturgeon, and *S. missouriensis* Miller, Lane & Unklesbay have their maximum whorl width and a revolving concave zone ventrad to their umbilical shoulders, but they also have depressed subelliptical sections and lack midventral saddles. The species was named in honor of the collector of the holotype, E. J. Bognar.

Occurrence.—1 specimen; Vanport unit: loc. Tl-1.

Repository.—Holotype OSU 18730.

Solenochilus cambridgensis Frontz, 1966
Pl. 1-32, fig. 1; pl. 1-33, fig. 4; pl. 1-39, fig. 2;
pl. 1-40, figs. 1, 2

Solenochilus cambridgensis Frontz, 1966, p. 433-436, figs. 1-3; Windle, 1970, p. 94-96, pl. 8, figs. 1, 2.

Diagnosis.—A very large *Solenochilus* characterized by a midventral depressed zone and by development of coarse adorally oblique corrugations extending from midventer to the flanks near the aperture of mature conchs.

Material.—The present species is based on three incomplete but very large, moderately well preserved internal molds that retain adoral portions of the phragmocones and adjoining parts of the living chambers. All appear to have been flattened somewhat dorsoventrally during fossilization. Frontz (1966, p. 434) compiled a number of dimensional data, several of which are summarized as follows: preserved length along venter: 340 to 356 mm; preserved length of body chamber: 150 to 270 mm; preserved length of phragmocone: 70 to 206 mm; height of outer whorl: 68 to 100 mm; width of body chamber: 200 to 270 mm; width of midventral depressed zone: 60 to 100 mm; depth of midventral depressed zone: 2 to 10.5 mm. It is estimated that the maximum conch diameter must have been close to 250 mm and may have been greater. The only approximate ratio determined is the H/W ratio: 0.26, 0.37, and 0.40, respectively, on each of the three specimens. We have examined the type specimens, and the following description is based not only on Frontz's and Windle's descriptions but also upon our observations.

Description.—Conch very large, nautiliconic, subglobose, moderately expanded adorally; adult whorl section subelliptical ventrally and laterally, broadly rounded in those surfaces but divided by a wide shallow median groove bearing two low longitudinal rounded ridges separated by a similar-sized trough, 60 to 100 mm wide and 2 to 10+ mm deep; whorl section abruptly rounded across ventrolateral zones apically and broadly rounded adorally, combined with dorsally convergent umbilical walls to form a single, broadly convex, lateral surface; dorsal surface poorly exposed but holotype having impressed zone approximately 75 mm wide and possibly 10 mm deep; one paratype (OSU 26790, pl. 1-33, fig. 4) having fragments of cross sections of two older whorls somewhat out of normal position, but presumably part of conch; oldest whorl 19 mm in diameter, evenly rounded ventrally, flattened laterally, and diverging dorsally; intermediate whorl having a maximum diameter of almost 100 mm, subtrapezoidal cross section, a much flattened to slightly concave venter, obtusely rounded ventrolateral shoulders, and flattened flanks diverging dorsad, increasing in divergence about two-thirds of distance across preserved sides; umbilicus small, details and measurements uncertain. Test largely exfoliated, moderately thick (3 to 4 mm), surface details unknown; both exterior and internal mold on ventral surface of living chamber on mature conchs marked by four pairs of prominent corrugations approximately 10 mm high and 60 mm apart, extending obliquely forward from midventer to middle on lateral flanks (pl. 1-32, fig. 1). Septal surfaces not exposed, sutures normally spaced 25 to 30 mm apart; on one paratype (OSU 26789) the last five septa orad spaced 18, 15, 10, and 8.5 mm apart, indicating a mature individual; sutures essentially transverse and slightly sinuous, forming a broad shallow lobe extending across venter, divided by a small median saddle, and bordered by broad, rounded, shallow, lateral saddles; dorsad extension of sutures unknown; siphuncle ventral and marginal in position and in contact with shell immediately posterior to contact of septum and wall; septal necks apparently hemichoanitic and connecting rings more or less cylindrical.

Remarks.—Mature individuals of this species can be identified readily by their large size, generally rounded ventral and lateral whorl profile, flattened and slightly concave venter, and their unique large corrugations extending obliquely forward from the midventer onto the lateral flanks. *Solenochilus brammeri* Miller, Dunbar & Condra (1933, p. 236) from the Argentine Limestone Member of the Wyandotte Formation is comparable in size but lacks the oblique corrugations. The trapezoidal whorl profile of the intermediate whorl of one of the paratypes (OSU 26790) is almost identical with the presumed adult whorl profile of *S. floweri* Gordon. Whether this similarity in whorl profile suggests that *S. floweri* is on the ancestral stem of *S. cambridgensis* or whether the similarity is a mere coincidence cannot be determined.

Frontz (1966, p. 436) stated that: "... it is likely that these corrugations were created by an inner thickening of the shell ...." This statement is not supported by observation of the internal mold and test. A fragment of enclosing matrix with adhering test which shows cross sections of three corrugations reveals that the test is uniformly 3 to 4 mm thick over the ridges and across the troughs, and that they truly are corrugations (pl. 1-39, fig. 2). These specimens are by far the largest fossil cephalopods collected to date from the Pennsylvanian System of Ohio. They were originally made available for Frontz's study and description by Randy Bates and the former John Gress and Sons limestone quarry at New Concord in Guernsey County.

Occurrence.—4 specimens total; Cambridge unit: Gwe-1.

Repository.—Holotype, OSU 26788; paratypes, OSU 26789, 26790, 29266.

Solenochilus greenensis Sturgeon, 1946

Pl. 1-31, figs. 1, 2; pl. 1-32, fig. 2;
pl. 1-33, fig. 3; pl. 1-34, figs. 1-3

Solenochilus sp. Sturgeon, 1937, p. 358.
Solenochilus greenensis Sturgeon, 1946, p. 12, 33-35, pl. 8, fig. 6, pl. 9, fig. 3, fig. 3A; Sturgeon & Miller, 1948, p. 78-79, pl. 19, figs. 1, 2; Furnish & Glenister, 1964, p. K439, K441, fig. 318, 2a, b.

Diagnosis.—A large species, but medium sized for *Solenochilus*; whorl section depressed and subelliptical, maximum whorl width below deep, prominent concave zone ventrad to umbilical shoulders, conspicuous rounded and elevated ridge overhanging mature umbilical wall on each umbilical shoulder, internal mold having numerous longitudinal lines adjacent to body chamber, a shallow, broadly rounded ventromyarian muscle scar, and sutures with a median ventral lobe.

Material.—Ten specimens of this species are available, nine from the Columbiana unit and one from the Washingtonville unit. Although none of these is complete, they do supplement each other well enough so that most of the salient features can be observed. Each consists of one-half whorl or less; among them they show many details of whorl cross profile, umbilical shoulder and wall, a small part of the apertural margin, surface ornament, ventromyarian muscle scar, siphuncle, sutures, and other details. Several conch dimensions cannot be precisely determined; those in table 1-22 are based on three selected specimens.

Description.—Conch large, subglobose, rapidly and regularly expanded; mature whorl section depressed, maximum width ventrad to revolving concave zone lying beneath umbilical shoulders; whorl section rounded ventrally without flattened median zone and merging over ventrolateral zone into convex but slightly flattened lateral surface beneath maximum width of whorl, rather sharply rounded over obtuse zone of maximum width and grading into wider revolving concave trough beneath narrowly rounded um-

TABLE 1-22.—*Conch measurements and ratios of* Solenochilus greenensis

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
OSU 18732 (cotype)	150[1]	25	74	96	0.63	0.77	1.07
OSU 19550 (hypotype)		25	90	115		0.77	
OSU 19553 (hypotype)	132	15[1]	65[2]	85[2]	0.65[2]	0.76[2]	1.13[1]

[1] Estimated measurement.
[2] Approximate measurement.

bilical shoulder, which is elevated into a sturdy rounded carina overhanging the umbilical wall; umbilical wall steep, definitely sigmoidal, having a definite concavity occupying about one-third of wall and a broad convexity covering remainder adjacent to umbilical seam; median one-fifth of dorsal surface slightly depressed (fig. 1-11B). Test variable in thickness, ranging from 1 mm to 4 mm, depending upon size of specimen and position upon the same specimen; 1 to 3 mm thick on smallest specimen to 2 to 4 mm thick on largest one; shell thickest in carinate umbilical shoulder, somewhat thinner on flanks, and thinnest along venter and in umbilical wall; surface ornament consisting of rather unobtrusive sinuous transverse lirae; on small specimens lirae trace a broad shallow ventral sinus and a nearly transverse course across ventrolateral, lateral, and umbilical surfaces; on one large specimen (OSU 28842, pl. 1-31, fig. 2) lirae much coarser on venter and lower flanks than on small specimens (such as OSU 28843, pl. 1-34, fig. 1), but fine and closely spaced above and delineating a broad shallow ventral sinus and a narrow sharply flexed loop on concave revolving zone before swinging orad parallel to umbilical shoulder and turning toward umbilicus across carinae or lateral spines, and then obliquely apicad across umbilical wall with a sharper bend near depressed dorsal zone. Internal mold smooth except for sutures, ventromyarian muscle scar, longitudinal lines, and a low rounded midventral ridge bordered on each side by a similar groove, indicating two ridges separated by a median conchal furrow on interior of shell; numerous longitudinal rounded lines and grooves on last camera of largest specimen, presumably extending apicad on phragmocone; slightly elevated bilobed retractor muscle scars on ventral and ventrolateral areas of apicad portion of living chamber on one hypotype (OSU 19550, pl. 1-34, fig. 2). Septa and sutures not well preserved or exposed; septa far apart on syntype (OSU 18731), 21 to 22 mm apart on venter or about one-fifth of whorl width, but only 6 to 7 mm apart adjacent to living chamber on largest specimen (OSU 19550); septa nearly transverse, possibly slightly oblique orad dorsally, moderately convex, more so from side to side; sutures slightly sinuous with a very shallow and narrow ventral lobe, weak ventrolateral saddles, nearly straight across the flanks, a small lobe at each of umbilical shoulders, nearly straight across umbilical wall, a small saddle at umbilical seam, and a shallow lobe across dorsal impressed zone; siphuncle suborthochoanitic, medium sized, apparent average diameter about 7 mm, ventral in position and in contact or nearly so with ventral conch wall; septal necks nearly straight, but on ventral side converging slightly apicad for a distance of 4 mm, there expanded rapidly and extended another 5 mm apicad, ending in a small gradual convergence; connecting rings long, thick walled, constricted at each end, nearly cylindrical, extending full length of septal necks; intervening cameral spaces completely lining the siphuncle (pl. 1-34, fig. 3).

Remarks.—*Solenochilus greenensis* can be recognized by its large subglobose conch that has a moderately depressed mature whorl section, maximum whorl width below revolving concavity ventrad to umbilical shoulders, carinate umbilical shoulders, overhanging umbilical wall, shallow broadly rounded ventromyarian muscle scar, and slightly sinuous sutures with a weak midventral lobe. The type and topotype material supplement each other well enough that the above composite description includes most of the conchal features with the exception of the lateral spines, earlier stages of growth, and some details of septa and sutures. The umbilical carina on certain specimens (for example, OSU 28842, pl. 1-31, fig. 2) suggests that the lateral spines were rounded ones similar to those of *Solenochilus* cf. *S. springeri* (White & St. John). On another specimen (OSU 19553, pl. 1-32, fig. 2), the umbilical carina is bluntly terminated, possibly indicating (1) the base of a broken spine, although no visible evidence of a healed break is visible, or (2) dimorphism, in which the shell of one sex was spineless. A mere fragment (OSU 18732) shows a short part of the adoral aperture enlarged into a flat band approximately 2 mm wide and estimated 0.5 mm high. The low, rounded longitudinal lines and grooves on the phragmocone of one adult specimen (OSU 19550) are similar to those of *S. peculiare* Miller & Owen and *S. millhorni* Sturgeon, Windle, Mapes & Hoare. However, *S. peculiare* has much-expanded siphuncular segments and appears to lack the prominent revolving concave zone beneath the umbilical shoulders, and *S. millhorni* is considerably larger and has a median ventral saddle.

Occurrence.—10 specimens total; Columbiana unit: 2 specimens each from locs. Mg-2 and Mg-7; 1 specimen each from locs. Cp-3, Cuc-1, Tg-2, Tw-1, and Twa-1; Washingtonville unit: 1 specimen from loc. Ss-5.

Repository.—Syntype, OSU 18731; paratypes, OSU 18732, 30618; hypotypes, OSU 19543, 19550, 19553, 28842, 28843, 29265, CWR 5358.

Solenochilus johnstoni Sturgeon, Windle, Mapes & Hoare, 1982

Pl. 1-35, figs. 1, 3

Solenochilus brammeri Windle, 1970, p. 92-94 (in part).
Solenochilus johnstoni Sturgeon, Windle, Mapes & Hoare, 1982, p. 1469, pl. 3, figs. 3, 4.

Diagnosis.—Large solenochilids having general features of the genus *Solenochilus* and characterized by rounded venter flattened or slightly concave along median zone, shallow ventral lobe bordered laterally by similar ventrolateral saddles, and shallow, but distinct, rounded lateral lobes.

Material.—Three incomplete large specimens and a fragment of a fourth that may be conspecific are tentatively referred to this species. The holotype (OSU 28841), an internal mold representing slightly less than half a whorl, and another specimen (OSU 30616 or 30617) consisting of thick-walled shell fragments of part of the venter, sides, and umbilical shoulder are from the Brush Creek unit. A third specimen (OSU 30619), from the Cambridge unit, has only the lateral outline of the body chamber and testiferous traces of the sides and umbilical shoulder preserved. In addition, there is a fragment of a very large lateral spine (OSU 30616 or 30617) some 90 mm in length from the Brush Creek unit. The following description is based mostly on the holotype. This internal mold of an immature specimen consists of about one-half of the outer whorl, divided almost equally between the phragmocone, consisting of four and a fraction camerae, and the apical portion of the body chamber. Measured along the midline of the venter the preserved distance is 255 mm, the maximum width is approximately 200 mm, and estimated conch diameter is at least 250 mm. The W/D ratio for the conch is about 0.75.

Description.—Conch large to very large, subglobose to globose, tarphyceraconic; whorl section elliptical ventrally and laterally with flattened to slightly concave venter, but broadly rounded in the overall and merging without distinct ventrolateral shoulders into slightly convex but flattened and more narrowly rounded flanks; sides definitely converging dorsally on upper one-third of preserved area, suggesting the possibility of a concave zone below each of the umbilical shoulders; uppermost part of sides, umbilical shoulders, and dorsum not preserved. Internal mold smooth except for median, ventral, flattened to slightly concave zone and a small, inconspicuous, but definite longitudinal groove about 8 mm on right side of midline of venter and siphuncle. Sutures only evidence of septa; sutures nearly transverse to conchal axis and slightly sinuous, forming a wide shallow ventral lobe, similar but slightly asymmetrical ventrolateral saddles, and a broad shallow lobe on each flank (fig. 1-12C); remainder of suture unknown; maximum spacing of septa and sutures 39 mm on venter, decreasing to 16 mm on upper part of preserved sides; siphuncle ventral and marginal, not well exposed; septal necks apparently short, 7 mm in middle camera but uncertain in other camerae, conical to cylindrical; connecting rings, if interpreted correctly, cylindrical, diameters slightly greater than those of septal necks; ectosiphuncular suture extending slightly more than half of cameral length of next apicad camera.

Remarks.—The two other large but specifically uncertain specimens of comparable size to the holotype do not reveal any additional physical features, except they do have shell preserved. The specimen from the Cambridge unit has shell thicknesses on the flanks and venter ranging from 1.5 to 3 mm. This specimen also has a remnant of a moderate-sized ridge on the umbilical shoulder. The large specimen from the Brush Creek unit consists of numerous shell fragments from the venter, sides, and umbilical walls of the body chamber; minimum restored length is 235 mm measured along the curvature, and thickness of test ranges from 2 to 6 mm, averaging 5 mm. Its umbilical shoulder is thick, strong, and rounded in a semicircular external pattern, delimiting a definite rounded ridge on the internal mold. The fragment of a large and sturdy lateral spine was collected at the same Brush Creek locality and may well be from the same species represented by the numerous thick shell fragments.

The large internal mold designated as the holotype approaches but does not attain the size of *S. brammeri* Miller, Dunbar & Condra and *S. cambridgensis* Frontz; it differs from *S. brammeri* in having a lobe instead of a straight suture across the whorl sides and from *S. cambridgensis* in not having a midventral saddle. Our specimen also lacks the oblique corrugations of *S. cambridgensis*, but those are features of adult specimens and ours is immature. In its lateral lobe our specimen is most like the lateral lobe of *S. missouriensis* Miller, Lane & Unklesbay from the Winterset Limestone of Missouri, but ours is immature and much larger than their holotype, which they interpreted as a mature specimen. *Solenochilus millhorni* Sturgeon, Windle, Mapes & Hoare is comparable in size, but has a midventral saddle and numerous long lines on the internal mold. The specific name was given to pay our respect to Mr. and Mrs. Fred Johnston, who generously gave the holotype for study purposes.

Occurrence.—4 specimens total, 3 doubtful; Brush Creek unit: 2 doubtful specimens from loc. Aa-41; 1 specimen from loc. Ale-33; Cambridge unit: 1 doubtful specimen from loc. Ls-1.

Repository.—Holotype, OSU 28841; questionable paratypes, OSU 30616, 30617, 30619.

Solenochilus mcfarlandi Sturgeon, Windle, Mapes & Hoare, 1982

Pl. 1-35, fig. 2; pl. 1-37, figs. 2, 3

Solenochilus brammeri Windle, 1970, p. 92-94 (in part), pl. 7, fig. 11.

Solenochilus mcfarlandi Sturgeon, Windle, Mapes & Hoare, 1982, p. 1469-1472, pl. 5, figs. 3, 4.

Diagnosis.—Small to medium-sized solenochilids having a subglobose conch, much depressed subelliptical whorl section, nearly straight ventral and lateral sutures, and strongly but narrowly lobate ventromyarian muscle scars.

Material.—Twelve specimens from the Brush Creek unit, nine from locality Cma-3 and three questionable specimens from locality Aw-51, represent this species. None is complete, each is at least slightly distorted, and most are largely exfoliated. The holotype (OSU 28854) consists of about half of an outer adult whorl. The total length along the outer preserved curvature is 190 mm; about one-third consists mostly of exfoliated phragmocone, and the remaining two-thirds consists largely of shell-covered body chamber. The eight paratypes range from approximately three-fourths of a whorl to a small fragment of a phragmocone showing parts of several camerae. Three small exfoliated additional fragments, one showing an umbilical opening and another a spine base, are questionably referred to this species. Exact measurements of the conch are difficult or impossible to ascertain because of distortion or incompleteness of the specimens. The following were determined on the holotype: D = 130 mm, U = 25 mm, H = 60 mm, W = 110 mm, W/D = 0.65, H/W = 0.55, U/D = 0.20.

Description.—Conch small to medium sized, tarphyceraconic, rapidly expanded, subglobose; whorl section depressed, subelliptical, maximum width along midregion of flanks; broadly rounded to flattened venter and more narrowly rounded flanks converging slightly dorsad into a shallow asymmetrical concave zone below dorsolateral shoulder, except on flanks of mature body chambers, where sides appear to be vertical or slightly diverging dorsad; umbilical shoulder slightly obtuse, carinate, a narrowly rounded ridge extending laterally, somewhat subdued on internal mold; umbilical wall not well preserved or exposed, apparently steep and slightly sigmoidal. Test 1 to 2 mm thick, in several layers, even thicker in umbilical shoulders; false color bands on innermost layer resulting from thin extensions of septa or secondary deposits onto inner surface of the outer shell, subequal in width and parallel to sutures, lighter colored (gray or pale brown) on orad side and wider and darker (brown or blue) on apicad side (pl. 1-37, figs. 2, 3); surface ornament consisting of very fine, indistinct growth lines marked at intervals in excess of 2 mm apart by stronger lines, best but not well shown on specimens OSU 28854 (pl. 1-37, fig. 3) and 28856; these lines indicating a very wide and very shallow hyponomic sinus on venter, more narrowly rounded saddlelike passage over ventrolateral areas, and a concave course orad across flanks; traces of lines on umbilical shoulders apparently similar in pattern to that on *Solenochilus greenensis*. Internal mold only visible on venter and flanks to umbilical shoulder, showing septa, sutures, siphuncle, and muscle scars on those areas. Only edges of septa exposed to view, spaced 7.5 to 13 mm apart along venter and decreasing to 4 to 5 mm apart below umbilical shoulders on holotype (OSU 28854); last four septa orad spaced 13, 10, 10, and 8 mm apart, presumably indicating a mature individual; sutures only very slightly sinuous, forming a very low midventral saddle, almost straight but

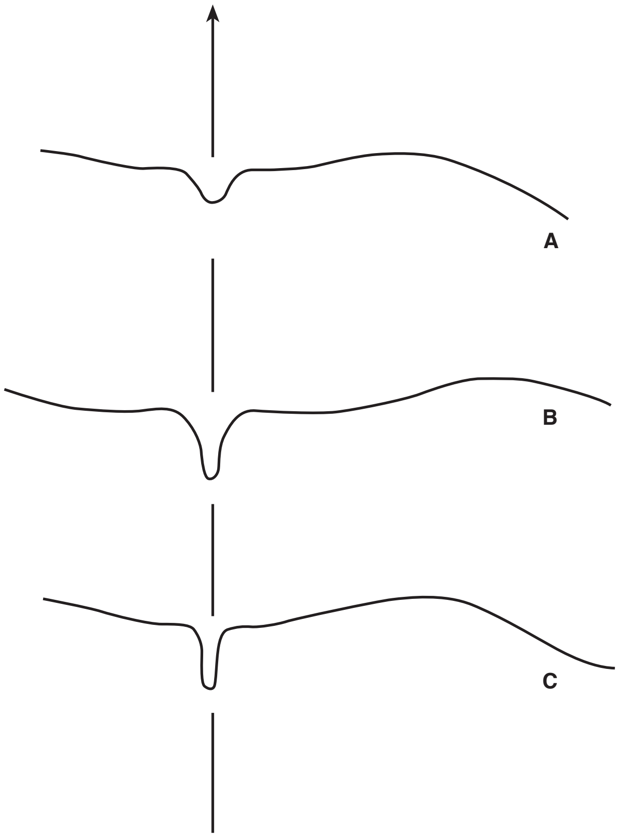

FIGURE 1-12.—External suture patterns from midventer to umbilical shoulder of three species of *Solenochilus*. Magnifications approximate.

A, *Solenochilus mcfarlandi* Sturgeon, Windle, Mapes & Hoare. Suture line on holotype at an estimated conch diameter of 90 mm characterized by a shallow but distinct, bluntly pointed, V-shaped ventral lobe (also see pl. 1-37, fig. 3) separated from the wide, shallow lateral lobe by a very slight saddle; the shallow lateral saddle is very broad and nearly symmetrical; remainder of the suture in the umbilical area not preserved; X $^{4}/_{5}$; Brush Creek unit, loc. Cma-3; OSU 28854.

B, *Solenochilus millhorni* Sturgeon, Windle, Mapes & Hoare. Composite suture pattern of holotype and a paratype, determined on exfoliated area of venter at a flattened whorl width of 175 mm (also see pl. 1-37, fig. 1, holotype); suture line has a pronounced, bluntly pointed, V-shaped ventral lobe (also see pl. 1-36, fig. 3, paratype) separated from a wide, shallow lateral lobe by a slight saddle; lateral saddle is broad, shallow, and nearly symmetrical; remainder of the suture in the umbilical area not exposed; X $^{3}/_{5}$; Putnam Hill-Vanport units undifferentiated, loc. Td-4; OSU 28844 (holotype), 28845 (paratype).

C, *Solenochilus johnstoni* Sturgeon, Windle, Mapes & Hoare. Suture line at an estimated conch diameter of 165 mm showing a deep, parallel-sided ventral lobe at the position of the siphuncle (also see pl. 1-35, figs. 1, 3); a slight saddle is developed between the pronounced ventral lobe and the shallow, slightly asymmetrical ventrolateral lobe; the broad, slightly asymmetrical lateral saddle is bordered by a rather deep umbilical lobe approximately at the position of the umbilical shoulder; X $^{2}/_{5}$; Brush Creek unit, loc. Ale-33; OSU 28841.

very shallow lobes on either side, an equally shallow ventrolateral saddle, and a nearly straight line across flanks to a small lobe below umbilical shoulder (fig. 1-12A); sutures not preserved across dorsum; siphuncle marginal and ventral in position, suborthochoanitic; septal necks sturdy, about 5 mm in diameter, extending two-fifths of distance across camerae (4 mm in 10 mm); connecting rings slightly expanded, cylindrical, diameter 6 mm (pl. 1-37, fig. 3); internal mold also marked on very small specimen (OSU 28858) by a broad and shallow midventral conchal furrow having a tiny ridge along its middle; numerous somewhat irregular lines on internal mold near aperture on right side of holotype apparently slickensides; ventromyarian muscle scar prominent, bilobed; lobes rather narrow and high, extending 14 mm orad of last septum, re-entrant between limited to about 5 mm beyond septum (pl. 1-37, fig. 3).

Remarks.—*Solenochilus mcfarlandi* is distinguished by a medium-sized subglobose conch that has a strongly depressed, ventrally rounded to almost flattened subelliptical whorl section, greatest width between the midflank region, carinate umbilical shoulders with small asymmetrical concave zones below the umbilical shoulders, almost straight sutures, nearly cylindrical siphuncle, slightly expanded connecting rings, and prominent narrowly bilobed ventromyarian muscle scar. *Solenochilus missouriensis* Miller, Lane & Unklesbay, the holotype of which we have had the privilege of examining, is comparable in size to our species, but has more widely spaced septa and much more sinuous sutures. Sutures of *S. brammeri* Miller, Dunbar & Condra are most like those of our specimens, but that species is much larger and has its maximum whorl width between the umbilical shoulders. *Solenochilus newlandi* (Hyatt) also has greatest conch width between noncarinate umbilical shoulders. *Solenochilus capax* (Meek & Worthen) lacks a lateral projection on the umbilical shoulder. *Solenochilus greenensis* Sturgeon is a larger species and has more sinuous sutures, a stronger concave zone below each umbilical shoulder, and wider lobes in the ventromyarian muscle scar. *Solenochilus springeri* (White & St. John) is about the same size as *S. mcfarlandi* and has a similar siphuncle and sutures, but has a deep hyponomic sinus and tapering connecting rings. *Solenochilus millhorni* Sturgeon, Windle, Mapes & Hoare has longitudinal lirae on the internal mold and more sinuous sutures and is also much larger. *Solenochilus mcfarlandi* was named for Harry McFarland, on whose farm literally thousands of fossil nautiloids were available in a thanatocoenose exposed by strip mining.

Occurrence.—12 specimens total, 3 questionable; Brush Creek unit: 9 specimens from loc. Cma-3; 3 doubtful specimens from loc. Aw-51.

Repository.—Holotype, OSU 28854; paratypes, OSU 28855 to 28858, 28870; doubtful specimen, OSU 28861.

Solenochilus millhorni Sturgeon, Windle, Mapes & Hoare, 1982

Pl. 1-36, fig. 3; pl. 1-37, figs. 1, 4

Solenochilus millhorni Sturgeon, Windle, Mapes and Hoare, 1982, p. 1472, pl. 5, figs. 1, 2.

Diagnosis.—Medium-large to large *Solenochilus* having a ventrally and ventrolaterally rounded depressed whorl section, revolving concave zone below each prominent, rounded, carinate, umbilical shoulder, and internal mold possessing numerous longitudinal lines and a median ventral saddle on each suture.

Material.—Three of four large fragmentary specimens certainly represent the species, and a smaller fragment also appears to belong to this taxon. All of these specimens are from the Putnam Hill unit or from the undifferentiated Putnam Hill-Vanport units. The holotype (OSU 28844) and a paratype (OSU 28845) were collected from the Putnam Hill-Vanport units at locality Td-4; a small fragmentary but recognizable internal mold (OSU 28846) came from locality Vel-15; and two specimens, one of which is tentatively assigned, were collected at locality Ms-3.

Description.—Conch medium-large to large; because of incompleteness and distortion, exact conch measurements and ratios indeterminable; maximum whorl width at least 175 mm and maximum preserved distance along venter of largest mashed specimens almost 250 mm; whorl outline broadly rounded ventrally with a definite tendency for midventral flattening; ventrolateral shoulders rounded, indistinct, and merged into both flanks and venter; flanks flattened and weakly convex; moderately deep, revolving concave trough below umbilical shoulder and a prominent, rounded carina; umbilical and dorsal surfaces not preserved. Test thick, variable, 3 to 4 mm or more in thickness, in several layers; surface ornament preserved only locally and consisting of rather fine growth lines. Internal mold possessing low but conspicuous, longitudinal, widely rounded bands spaced 1.5 to 3 mm apart and separated by wider, flat-bottomed troughs at least on venter; numerous finer lines on innermost shell layer between these lirae, and a wide, shallow, rounded conchal furrow toward orad end of holotype; septa, where preserved, nearly transverse, spaced approximately 20 to 25 mm apart on paratype OSU 28847, which is apparently a mature or nearly mature specimen. Sutures slightly sinuous (fig. 1-12B), small median ventral saddle bordered laterally by rather narrow ventral lobes, and in turn by broad ventrolateral saddles on paratype OSU 28845; sutures not visible beyond limits of venter; siphuncle ventral and marginal, nearly orthochoanitic, rather small, ranging in exposed ventral diameter from 3 mm or less to about 8 mm; septal necks extended apicad about one-half the cameral length, gradually tapered, more so at end; connecting rings apparently slender, cylindrical, extended full length of camerae.

Remarks.—The lines on the internal mold of this large species of *Solenochilus* suggest *S. greenensis* Sturgeon and *S. peculiare* Miller & Owen. It seems to have more features, including rounded and carinate umbilical shoulders, a revolving concavity beneath those shoulders, and similar siphuncle, but is not conspecific with either species. Both are smaller than the species under consideration, and, in addition, *S. greenensis* has a median ventral lobe instead of a saddle. *Solenochilus peculiare* does have a median ventral saddle, but its much smaller adult size, expanded connecting rings, apparent lack of a concave zone below the umbilical shoulder, and older stratigraphic position suggest that it is a separate species. Other large species of *Solenochilus*, such as *S. brammeri* Miller, Dunbar & Condra, *S. cambridgensis* Frontz, and *S. johnstoni* Sturgeon, Windle, Mapes & Hoare, lack visible lines on the internal mold and have other conchal differences. The specific name was given to acknowledge the contribution to the paleontology of the Pennsylvanian System in Ohio by Mr. and Mrs. L. J. Millhorn of Sherrodsville, Ohio, who generously gave the holotype, a paratype, and numerous other specimens for our studies.

Occurrence.—5 specimens total; Putnam Hill and Putnam Hill-Vanport undifferentiated units: 2 specimens each from locs. Ms-3 and Td-4, 1 specimen from loc. Vel-15.

Repository.—Holotype, OSU 28844; paratypes, OSU 28845 to 28848.

Solenochilus peculiare Miller & Owen, 1934
Pl. 1-36, figs. 1, 2

Solenochilus peculiare Miller & Owen, 1934, p. 194, 254-256, pl. 19, figs. 1, 2; Sturgeon, 1938, p. 277-279, pl. 1, figs. 1-3.

Diagnosis.—Medium-sized to large *Solenochilus* having a depressed subelliptical whorl section, longitudinally lirate internal mold, and median ventral saddle.

Material.—Two specimens from the Lower Mercer unit in Hocking and Stark Counties are definitely assigned to this species, and a third specimen from the Lowellville (Poverty Run) unit in Tuscarawas County is tentatively identified as a representative. The Stark County specimen (OSU 10128) closely resembles Miller & Owen's holotype, which we have observed. The Hocking County specimen is much flattened and shows the characteristic pattern of the siphuncle. The Tuscarawas County specimen is mashed inward along the venter, does not show any details of septa or siphuncle, and is referred to this species with hesitation. All specimens are incomplete and are estimated to consist of approximately one-half outer whorl showing parts of the body chamber and phragmocone. The following description is based mostly on the Stark County specimen, which consists of a slightly distorted and largely exfoliated internal mold revealing the ventral and ventrolateral portion of eight or nine camerae and much of the body chamber. The phragmocone appears to have retained the innermost shell layer and consequently is glossier and smoother than the body chamber. The preserved part of the conch has a length of 180 mm measured along the venter, whorl width of about 90 mm at the junction of the body chamber and the phragmocone, and an estimated conch diameter of 150 mm.

Description.—Conch medium sized for representatives of *Solenochilus*, rapidly expanded, subglobose, tarphyceraconic to weakly nautiliconic; whorl section broadly rounded ventrally, more narrowly rounded laterally, without definite line of demarcation on ventrolateral surfaces; no details of umbilical shoulders, umbilical wall, or dorsum preserved. Test rather thin, 1 to 1.5 mm thick; surface ornament unknown. Internal mold longitudinally lirate, lines closely spaced and of two different strengths, more conspicuous on phragmocone and along midventer, where larger lirae spaced more than 1 mm apart and separated by one or two smaller intervening lirae; lateral lirae also smaller. Septa 11 to 12 mm apart except the four orad ones, which are 8, 6, and 5 mm apart, respectively, toward the living chamber, suggesting a mature individual; sutures slightly sinuous, preserved portions forming a shallow, broadly rounded ventral saddle bordered on each side by a similar lobe, and lobes in turn by similar ventrolateral saddles; siphuncle ventral and marginal, its segments expanded (fig. 1-13); septal necks extended about three-sevenths of distance across a normal camera, expanded in diameter a short distance beyond septum and contracted rather abruptly at apicad end; connecting rings pyriform in shape, rapidly expanded near orad end and apparently tapering gradually toward apicad end, exceeding septal necks in maximum diameter as well as in length; in one camera, connecting-ring and septal-neck lengths and maximum diameters equaling 6 and 4.5 mm and 6 and 3 mm, respectively; in shortened camerae adjacent to living chamber, structure and dimensions of siphuncle presumably modified but not well shown.

Remarks.—Comparison of our Stark County specimen

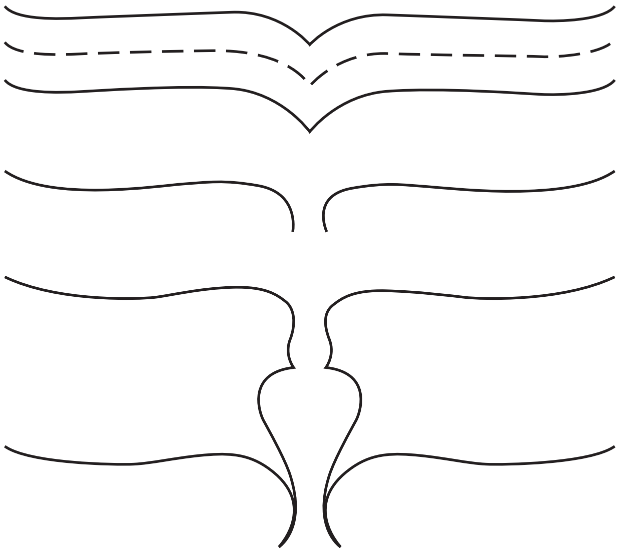

FIGURE 1-13.—*Solenochilus peculiare* Miller & 0wen. Diagrammatic midventral view of a portion of exfoliated venter on a hypotype adjacent to body chamber showing some details of siphuncle and sutures; approx. X2; Lower Mercer unit, loc. Sc-2; OSU 10128 (also see pl. 1-36, fig. 1). After Sturgeon (1938).

(OSU 10128) with Miller and Owen's holotype from Missouri verified that they are very much alike in size and shape, manner of preservation, and in details of longitudinal lirae on the internal mold, septal spacing, suture pattern and dimensions, and physical features of the siphuncular segments; thus they are undoubtedly conspecific. This Ohio specimen was collected by H. H. Wolf from the Lower Mercer limestone in Canton in the 1890's but was not identified until the 1930's (Sturgeon, 1938). Our Hocking County specimen (OSU 28864) is a flattened and slightly distorted fragment that was originally shell covered; it measures 145 mm long and 135 mm wide. Removal of test from a midventral area near the apicad end disclosed sutural and siphuncular (at least in the septal necks) patterns (pl. 1-36, fig. 2) similar to those of *Solenochilus peculiare*. On the basis of its suture pattern, structure of the siphuncle, and occurrence in the Lower Mercer unit, this specimen is likewise, but with less certainty, referred to Miller and Owen's species. The Tuscarawas County specimen is comparable in size and shape to that of the holotype and to our Stark County specimen but does not show features of the camerae, septa, sutures, or siphuncle. It is therefore questionably referred to *S. peculiare* on the basis of its size and stratigraphic occurrence in the Lowellville (Poverty Run) unit, which is a marine unit close below the Lower Mercer unit in Ohio. These criteria, however, are unreliable for positive identification.

Occurrence.—3 specimens total, 1 doubtful; Lowellville (Poverty Run) unit: 1 doubtful specimen from loc. Tfr-1; Lower Mercer unit: 1 specimen each from locs. Hfg-5 and Sc-2.

Repository.—Hypotypes, OSU 10128, 28864; doubtful specimen, OSU 28865.

Solenochilus cf. *S. springeri* (White & St. John), 1868
Pl. 1-38, figs. 1, 2

Nautilus (Cryptoceras) springeri White & St. John, 1868, p. 124-125, fig. 10.

Nautilus (Solenochilus) springeri Meek & Worthen, 1870, p. 47-49.

Solenochilus springeri Furnish & Glenister, 1964, p. K440, K442, figs. 319, 321; Mikesh & Glenister, 1966, p. 273-277, figs. 1A, B.

Diagnosis.—Medium-sized *Solenochilus* whose lateral spines have a pronounced forward curvature (see fig. 1-10).

Material.—Eight fragmentary and immature specimens, several of questionable identity, from the Putnam Hill unit are compared with this species. The best specimen (OSU 28850) unfortunately is mashed but does have preserved surface ornament, part of the umbilical shoulder, part of the apertural margin, and the entire left lateral spine. Another specimen (OSU 28851), which is a little distorted and partially exfoliated, retains part of the umbilical shoulder. Most conch measurements and ratios cannot be determined and those ascertained are only approximate. Maximum conch diameter is at least 150 mm and maximum diameter of the umbilicus possibly 30 to 35 mm. Length of the lateral spine along its curvature is about 90 mm.

Description.—Conch medium sized, venter and ventrolateral and lateral surfaces fully rounded, revolving concave zone below umbilical shoulders; rounded umbilical shoulders elevated into carinate dorsolateral ridge, enclosing an even more narrowly rounded ridge on internal mold, and overhanging the umbilical wall; maximum width of conch ventrad to concave zone below umbilical shoulders. Test more than 1 mm thick, almost smooth, marked by numerous fine growth lirae uniformly spaced except on ventrolateral surface, where stronger lirae 1+ mm apart crossed by equally strong and equally spaced longitudinal lirae form a reticulate pattern (pl. 1-38, fig. 2); lirate pattern somewhat distorted by crushing of shell but apparently similar to that of *S. greenensis* on umbilical shoulder, on concave zone below, and on lateral spine; preserved apertural margin showing a wide shallow re-entrant below base of lateral spine, a broad, rounded forward convexity on flanks, and a broad, apparently shallow hyponomic sinus; dorsolateral ridge extended into a definitely forward-curved thick-walled, hollow lateral spine, rounded on posterior and ventral surfaces, but angular along contact line of enrollment on anterior surface. Internal features of septa, sutures, and siphuncle only visible on two smaller specimens (OSU 28859 and 28863); septa relatively far apart, 13 to 15 mm on conchs having diameters at least 65 to 75 mm; sutures nearly straight, with a small shallow midventral lobe bordered by wide low saddles extended as far as visible across ventrolateral zones and flanks; siphuncle poorly preserved on one specimen and not well exposed on the other; septal necks nearly straight, extending 5 mm in a cameral distance of 14 mm, and 6 mm in a distance of 15 mm, or about two-fifths of cameral distance, diameter at least 3 mm; connecting rings preserved only on poorly exposed specimen, apparently greater in diameter than that of septal necks, shape of rings not fully discernible.

Remarks.—As far as can be observed, our spine-bearing specimen (OSU 28850) is similar in size, shape, surface ornament, and spines to those features of *Solenochilus springeri* (White & St. John) as described by Mikesh and Glenister (1966, p. 273-277, figs. 1A, B; also see our fig. 1-10) from Arkansas and Iowa specimens. Although the lateral spine on our specimen (pl. 1-38, fig. 1) is similar in length and structural details to the spines on Mikesh and Glenister's specimens, it does have a more pronounced original curvature than the spines on their specimens. Present curvature of our specimen's spine is greatest along the basal half of the spine, intermediate along the shoulder, and least along the outer half of the spine. The radius of curvature is reciprocal to the curvature; table 1-23 lists these variations in curvature. Specimen OSU 28851 is much less distorted and broken than the spine-bearing individual (OSU 28850); the rotund nature and concave zone below the umbilical shoulder of the conch are best observed on this specimen. Even those specimens lacking lateral spines are believed to belong to this species because they agree in general observable features of the spine-bearing specimen (OSU 28850) and were collected from the same stratigraphic sources. The fragments of spines, dorsolateral shoulders, and shell parts from two or more specimens are believed to belong to the same species, as the fragments are similar to comparable parts on the above specimens and are also from the same stratigraphic sources.

TABLE 1-23.—*Conch measurements and curvature radii of* Solenochilus *cf.* S. springeri[1]

Position	Length (mm)	Radius of curvature (degrees)
Dorsolateral (umbilical) shoulder	38	33.4
Basal part of lateral spine	41	28
Terminal part of lateral spine	50	68.2

[1] As measured on specimen OSU 28850.

Occurrence.—8 specimens total, 1 or more doubtful; Putnam Hill and Putnam Hill-Vanport undifferentiated units: 5 specimens from Ms-3; 1 specimen each from locs. Td-4, Vel-15, and Vel-19.

Repository.—OSU 28850 to 28853, 28859, 28863.

Solenochilus sp.
Pl. 1-39, fig. 1

Diagnosis.—Medium-sized *Solenochilus* characterized by a depressed subelliptical whorl section and a subangular umbilical shoulder.

Material.—The only available specimen is a fragment of a medium-sized exfoliated *Solenochilus* consisting of part of the body chamber and two camerae, together equaling less than half a whorl. Discernible approximate conchal measurements and ratios are: D (est.) = 130 mm, H = 72 mm, W = 108 mm, W/D = 0.80, H/W = 0.67.

Description.—Conch medium sized for *Solenochilus*, subglobose, tarphyceraconic to nautiliconic; whorl section depressed, subelliptical, being broadly rounded to flattened ventrally, more narrowly rounded laterally, and extending dorsad in a rounded, convex to subangular umbilical shoulder (fig. 1-11C); umbilical walls sigmoidal, with a concavity adjacent to umbilical shoulder and a convexity along a median dorsal depressed zone 22 mm wide and 6 mm deep. Remnants of two camerae and septa preserved at apicad end; septa spaced about 16 mm apart; suture remnants not well preserved but indicating a low, narrow, median ventral saddle bordered by shallow lobes, a broadly rounded, shallow saddle across dorsolateral zone and umbilical wall, and a widely flaring, V-shaped dorsal lobe; ventral siphuncle having one preserved septal neck approximately 5 mm long and 8 mm in apparent maximum diameter.

Remarks.—Ratio of height to width of the whorl, septal spacing, and umbilical shoulder suggest *Solenochilus kentuckiensis* Hyatt, but its nearly straight suture pattern makes identification with that species doubtful. This specimen is one of two representatives of *Solenochilus* from the Washingtonville unit in our collection.

Occurrence.—1 specimen; Washingtonville unit; loc. MUmu-1.

Repository.—OSU 28860.

Genus *Liroceras* Teichert, 1940

Type species: *Coloceras liratum* Girty, 1911; OD

Coloceras Hyatt, 1893, p. 449-452, figs. 25-27 (*non* Taschenberg, 1882); 1900, p. 523; 1913, p. 604; Miller, Dunbar & Condra, 1933, p. 128-132, fig. 22.

Coloceras globatum Hyatt, 1894, p. 541-543, 602-603, pl. 10, fig. 14.

Liroceras Teichert, 1940, p. 590; Miller & Youngquist, 1949, p. 120-121; Kummel, 1964, p. K445-446, figs. 324, 3a, b; Gordon, 1964, p. 155-156; Turner, 1965, p. 252; Windle, 1970, p. 96-99.

Diagnosis.—Small to medium-sized subglobose nautilicones having a small umbilicus and mature reniform whorl section.

Description.—Conch smooth, mostly small to medium sized, rapidly expanded, nautiliconic, W/D ratio approximately 0.80; mature whorl section depressed and reniform in outline, broadly rounded ventrally, more narrowly rounded laterally, and impressed dorsally; umbilicus small, U/D ratio approximately 0.25 to 0.30; siphuncle variable in position, never at periphery.

Remarks.—*Liroceras* can be distinguished from related and similar genera by features of the conch, whorls, septa, and sutures, and by size differences. *Condraoceras* Miller, Lane & Unklesbay and *Peripetoceras* Hyatt have more nearly circular whorl sections. *Coelogasteroceras* Hyatt has flattened whorl sides and, at maturity, a sulcate venter. *Ephippioceras* Hyatt has a subacute ventral saddle, and *Megaglossoceras* Miller, Dunbar & Condra has a broad, tongue-shaped ventral saddle. Other somewhat similar appearing genera such as *Leuroceras* Hyatt, *Planetoceras* Hyatt, and *Stearoceras* Hyatt differ from *Liroceras* in manner of coiling, suture patterns, and whorl sections.

Establishment of the genus *Liroceras* has had a rather involved history. Specimens now referred to that genus were formerly placed in the genus *Coloceras* Hyatt, 1893. Hyatt (1893, p. 451) designated as types: " . . . the specimens described above from Visé, De Koninck Coll. Mus. Comp. Zool., supposed to belong to *C. globatum*, sp. De Kon." De Koninck (1878, p. 95-96) had originally assigned those specimens to *Nautilus globatus* Sowerby, but Hyatt believed that certain of De Koninck's examples were not congeners of Sowerby's species. Later, Hyatt (1893) designated those questionable individuals as types of a new genus, *Coloceras*. In the following year, Hyatt (1894, p. 541-543, pl. 10, figs. 1-14) discussed *Coloceras* again and illustrated those De Koninck specimens selected as types. Miller, Dunbar & Condra (1933, p. 129) stated that none of Hyatt's types are mature and that variation among them suggests that not all are conspecific. They added that because none of the specimens designated by Hyatt as types of *Coloceras* can be referred to *N. globatus* Sowerby, they are without a specific name. Those same authors then proceeded to select one of Hyatt's specimens (1894, pl. 10, fig. 14) as the holotype (lectotype) of a new species, *C. hyatti*, which in turn was designated as the type of the genus *Coloceras*. In 1940, Teichert (p. 590) believed *Coloceras* Hyatt to be a junior homonym of *Coloceras* Nitzsch, 1882. That assumption was, however, an error, as Turner (1965, p. 252) noted that Nitzsch had no publication of that date. It was undoubtedly mistaken for Taschenberg (1882, p. 42), who had used *Coloceras* as a subgenus for a mallophagan insect. *Coloceras* Hyatt, 1893 is, therefore, a junior homonym for *Coloceras* Taschenberg, 1882. Teichert's (1940) selection of a new generic name is, however, valid; he proposed the name *Liroceras* for *Coloceras* Hyatt and designated *C. liratum* Girty as the type species. He included all species referred to *Coloceras* Hyatt by Miller, Dunbar and Condra (1933) (but their type species, *C. hyatti*, only tentatively) and all American species of *Coloceras* described between 1933 and 1940. Some species are intermediate between *Liroceras* and *Coelogasteroceras* and can be assigned to one or the other only with difficulty.

Liroceras is widely distributed in the Northern Hemisphere in strata ranging in age from Late Mississippian into the Permian. Inspection of available references indicates that a minimum of two dozen species have been referred at least tentatively to the genus, including seven Mississippian species, 12 Pennsylvanian species, and five Permian species. Geographic sources are Asia (China), three species; Europe (England, Ireland), four species; and North America (Mexico, United States), 17 species. In Ohio, Morningstar (1922, p. 269) first reported *Coloceras* [*Liroceras*] from the Sharon ironstone and the McArthur (Putnam Hill) limestone. Sturgeon (1937, p. 357; 1946, p. 19-21, pl. 4, figs. 6-9), Murphy (1970, p. 203-204, pl. 36, fig. 9), and Windle (1970, p. 99-101, pl. 7, figs. 3-6) described and illustrated additional Ohio specimens of *Liroceras* from the Hamden (Columbiana) and Brush Creek units. In Pennsylvania, Miller and Unklesbay (1942b, p. 137-138, pl. 1, figs. 11-13) briefly described and illustrated more specimens from the Brush Creek and Vanport units; Windle (1970, p. 101) also noted other Pennsylvania examples from the Brush Creek unit and possibly from the Carnahan Run and the Woods Run units.

Geologic range.—Mississippian-Permian.

Liroceras liratum (Girty), 1911
Pl. 1-44, figs. 1, 3-12

Coloceras liratum Girty, 1911, p. 144-145; 1915, p. 237-238, pl. 28, figs. 2-6a; Miller, Dunbar & Condra, 1933, p. 132-134, pl. 6, figs. 1-8; Sturgeon, 1937, p. 357.
Coloceras liratum var. *obsoletum* Girty, 1911, p. 145; 1915, p. 238-239, pl. 29, figs. 1-3a.
Coloceras obsoletum Miller, Dunbar & Condra?, 1933, p. 134-136, pl. 7, figs. 4-7.
Coloceras sp.? Morningstar, 1922, p. 269.
Liroceras liratum Teichert, 1940, p. 590; Sturgeon, 1946, p. 12, 19-21, pl. 4, figs. 6-9; Sturgeon and associates, 1958, pl. 10, figs. 12, 13; Hoare, 1961, p. 133, pl. 16, fig. 7; Unklesbay, 1962, p. 45-47, pl. 5, figs. 6-8, pl. 6, figs. 5, 6; fig. 1A; Murphy, 1970, p. 203-204, pl. 36, fig. 9; Windle, 1970, p. 99-101, pl. 7, figs. 3-6.
Liroceras sp. Miller & Unklesbay, 1942b, p. 137-138, pl. 1, figs. 11-13; figs. 1A, B; Sturgeon & Miller, 1948, p. 76-77.

Diagnosis.—*Liroceras* characterized by a distinct reticulate surface pattern on and adjacent to the umbilical shoulders in immature growth stages.

Material.—We have approximately 130 specimens of this rather uniform and long-ranging species that are almost equally divided in source between the Brush Creek unit of the Conemaugh Group and the several marine units of the Allegheny Group. Except for the Brush Creek specimens and a doubtful fragment reported by Morningstar from the Sharon ironstone of the Pottsville Group, the known stratigraphic distribution of this species in Ohio is essentially that of the Allegheny Group. All specimens are incomplete, and it is interesting to note that many of them are preserved in a similar manner—consisting of much of the living chamber and the ultimate septum, with or without several additional septa and camerae of the phragmocone. There are several more complete specimens, including one (OSU 18710) largely exfoliated immature specimen, another (also OSU 18710) longitudinally polished apparently mature and nearly complete specimen, and a third (OSU 29165) somewhat damaged and also nearly mature and complete specimen. The largest specimens must have had maximum conch diameters of 25 to 30 mm and the body chamber occupying less than one-half of the outer whorl. Conch measurements and ratios (table 1-24) are limited because of the prevalent incomplete preservation.

Description.—Conch small to small-medium, subglobose, nautiliconic, consisting of approximately two whorls; umbilicus moderately narrow and perforate; mature whorl depressed, reniform in cross section, broadly rounded ventrally with flattened or weakly concave median region, and continuously but more narrowly rounded laterally; umbilical shoulders obtusely rounded; umbilical wall steep and slightly convex; dorsal surface impressed, depth of impressed zone negligible in immature whorls but attaining a depth of 3 mm and a width of more than 10 mm in mature whorls; width of impressed zone approximately one-third of whorl

TABLE 1-24.—*Conch measurements and ratios of* Liroceras liratum

Specimen	D (mm)	U (mm)	H (mm)	W (mm)	W/D	H/W	U/D
OSU 18710[1] (hypotype)	23.5						
OSU 18710[1] (hypotype)	20.3	5.9	10.4	15.5	0.76	0.67	0.29
OSU 18712 (hypotype)			13	24		0.54	
OSU 18748 (hypotype)			13	23		0.56	
OSU 18749 (hypotype)			11.7	17.3		0.68	
OSU 29165[1] (hypotype)	31	9.2	16.2	27.3	0.90	0.60	0.30
OSU 29165[1] (hypotype)			16	26.8		0.60	
OSU 29165[1] (hypotype)			14.3	22.5		0.63	

[1] More than one specimen with same catalog number.

width; umbilicus small, steep walled, and deep; perforation rounded (pl. 1-44, fig. 8); initial whorls subelliptical in cross section. Test thin, marked by numerous rather fine incremental lirae indicating a moderately deep, rounded, V-shaped ventral sinus (pl. 1-44, fig. 11), a broad, rounded convexity orad on each flank, and a nearly straight course across umbilical wall; on umbilical shoulder and adjacent areas, more widely spaced longitudinal lirae also present, forming a reticulate pattern on umbilical shoulders and walls, seemingly restricted to immature specimens and possibly only to certain ones (pl. 1-44, figs. 3, 4). Septa slightly oblique to axis of coiling, ventral margin extended orad, more so with growth, spaced 2 to 3 mm apart; older sutures faintly sinuous and nearly transverse, mature sutures consisting of a broad, shallow ventral lobe, a nearly straight line across flanks and umbilical shoulders, a faint dorsolateral lobe, a small pointed saddle at umbilical seam, and a rounded dorsal lobe; mold of ventral interior having a small elevated line indicating presence of a conchal furrow; siphuncle small, 1 to 1.5 mm in diameter, located between center and dorsum of whorl (pl. 1-44, fig. 5), orthochoanitic, septal necks and connecting rings almost straight.

Remarks.—*Liroceras* specimens from Ohio differ in no important feature from other known specimens of *L. liratum*, except possibly in a closer spacing of septa. The reticulate surface ornament on the umbilical shoulders and adjacent areas is unique among American species of the genus. Unklesbay (1962, p. 46) found that *L. obsoletum* (Girty), originally separated as a variety because of no apparent reticulate surface markings and a more central position of its siphuncle, exhibits complete transition with *L. liratum*. *Liroceras greeni* (Miller, Dunbar & Condra) is a larger species having a wider umbilicus, and *L. milleri* (Newell) is a very large species having an imperforate umbilicus.

Occurrence.—130 specimens total, several questionable; Brush Creek unit: 53 specimens from loc. Aa-41, 10 specimens from loc. Ale-35, 1 specimen each from locs. Ale-18 and Cma-3; Columbiana unit: 10 specimens from loc. Mg-2; 9 specimens from loc. Mg-7, 7 specimens from loc. Mg-10, 4 specimens each from locs. Cp-3 and Ss-4, 2 specimens each from locs. Cs-3 and Cuc-2, 1 specimen each from locs. Cs-7 and Ss-5; Putnam Hill unit: 5 specimens from loc. Ms-3, 3 specimens from loc. Mc-1, 2 specimens from loc. Mg-3, 1 specimen each from locs. Hg-6, Jje-2, MUsp-1, Ty-3, and Vel-15; Sharon unit: 1 specimen from loc. SCp-2; Vanport unit: 1 specimen each from locs. Mp-1 and Tl-1; Washingtonville unit: 4 specimens from loc. MUmu-1, 1 specimen each from locs. CAr-2 and Cs-5; Zaleski unit: 1 specimen from loc. Vel-13.

Repository.—Hypotypes, OSU 18710 to 18712, 18748, 18749, 19603, 28827 to 28832, 29165, 29260, 29308.

Genus *Coelogasteroceras* Hyatt, 1893

Type species: *Coelogasteroceras coxi* Gordon, 1960 (*nom. nov. subst. pro Nautilus canaliculatus* Cox, 1858, *non* Eichwald, 1857); OD

Solenoceras Hyatt, 1884, p. 286.

Coelogasteroceras Hyatt, 1893, p. 392, 447; 1894, p. 498-499, 519, pl. 10, fig. 33; 1900, p. 524; 1913, p. 605; Miller, Dunbar & Condra, 1933, p. 211-213, pl. 14, figs. 1, 2; Miller & Youngquist, 1949, p. 124-125; Kummel, 1964, p. K446-K447, figs. 324, 2a, b; Gordon, 1964, p. 158-159; Windle, 1970, p. 102.

Coelogasteroceras coxi Gordon, 1960, p. 138-139.

Diagnosis.—Very similar to *Liroceras* but differs noticeably in the possession of a sulcate venter on mature whorl.

Description.—Conch small to medium sized, subglobose, nautiliconic; whorl section slightly depressed, laterally flattened, ventrally grooved, converging toward venter; maximum width at or below umbilical shoulders; umbilicus moderately small; sutures with shallow ventral and lateral lobes; siphuncle subcentral.

Remarks.—*Coelogasteroceras* is similar to and closely related to *Liroceras*, but differs from that genus in the possession of a less depressed whorl section, flattened flanks, and sulcate venter on adult conchs. The sulcate venter is the most distinctive feature of the genus; it is deep and obvious on *C. coxi* and shallow and inconspicuous on *C. dubium*.

Geologic range.—Pennsylvanian-Permian.

Coelogasteroceras dubium Miller & Unklesbay, 1947
Pl. 1-44, fig. 2

Coelogasteroceras dubium Miller & Unklesbay, 1947, p. 320-321, pl. 1, figs. 5, 6; Windle, 1970, p. 102-104, pl. 7, figs. 7, 8.

Liroceras dubium Murphy, 1970, p. 204-205, pl. 36, fig. 8.

Diagnosis.—Similar to *Liroceras liratum* (Girty) but having a midventral sulcus developed at least on the adoral portion of mature body whorls.

Material.—Only one specimen (USNM 161421) of this species, previously described by Murphy (1970), is known to have been collected in Ohio. The holotype (CM 25790), a paratype (CM 25791) and three topotypes (SUI 7990A-C) were collected at localities in western Pennsylvania. The types were not available, but we had opportunity to study Murphy's hypotype and the University of Iowa's topotypes. All specimens are from the Brush Creek unit and none is complete. The hypotype (USNM 161421), is nearly complete but somewhat mashed; the primary types and the topotypes each consist of less than one whorl. The following measurements and ratios are based on the holotype and the Ohio hypotype (the measurements in part are from Miller and Unklesbay and from Murphy); holotype (CM 25790): D = 28 mm, U = 9 mm, H = 10 mm, W = 17 mm, W/D = 0.88, H/W = 0.60, U/D = 0.32; hypotype (USNM 161421): D = 25.7 mm, U = 8.5 mm, H = 14.7 mm, W = 20 mm, W/D = 0.78, H/W = 0.74, U/D = 0.33. On the holotype the septa are about 4 mm apart, except the last three orad, which are about 2 mm apart. On one topotype (SUI 7990A) the last four septa are 3, 2.4, and 1.6 mm apart adjacent to the living chamber. These septal spacings indicate both are mature specimens.

Description.—Conch small to small-medium, subglobose to globose, rapidly to moderately expanded, nautiliconic; whorls depressed, reniform, broadly rounded ventrally and ventrolaterally, shallow midventral sulcus at least on mature body chamber; umbilical shoulder rather narrowly rounded but slightly obtuse; umbilical wall steep and slightly convex; dorsum weakly impressed. Test less than 1 mm thick, averaging about 0.5 mm thick, thickest in and near umbilical shoulders, attaining there a thickness of 0.7 mm; surface marked by numerous fine growth lines, tracing a moderately broad and rather deep rounded ventral sinus, broadly rounded slightly asymmetrical lateral salients, and nearly straight courses across umbilical walls; one specimen (USNM 161421) showing several quite visible longitudinal lirae on umbilical shoulders; lirae in turn separated by several intervening less conspicuous lines continuing onto ventrolateral surfaces beyond the more conspicuous lines. Internal mold smooth except for slight trace of midventral sulcus on living chamber, very small midventral longitudinal ridge indicating a tiny conchal furrow, and sutures; sutures nearly transverse, slightly sinuous, forming a broad shallow ventral lobe bordered by a similar ventrolateral saddle on each side, no further trace visible dorsad; siphuncle unknown.

Remarks.—This species closely resembles *Liroceras liratum* (Girty) in size, conch and whorl form and ratios, general surface ornament, and suture pattern. It differs from *L. liratum* in having a narrower whorl section and a midventral sulcus on the mature body chamber of all specimens; the sulcus continues along the venter apicad on some specimens. The boundary between these two species is indeed indistinct, as some specimens of *L. liratum* have a faint sulcus, and specimen USNM 161421 has a reticulate lirate pattern on the umbilical shoulder. Because the latter specimen does show a sulcus along the venter as far as exposed (pl. 1-44, fig. 2), we are retaining the species in the genus *Coelogasteroceras*. If it were not for this extended sulcus on this one specimen, we would have followed Murphy (1970, p. 205) in placing the species in the genus *Liroceras*, to which, as previously mentioned, it is closely akin. We do agree, however, with Miller and Unklesbay (1947, p. 321) “that it is closer to *C. canaliculatum* [now *C. coxi*] than to any other genotype.” It is true, as Murphy (1970) noted, that the sulcus is much weaker than on *C. canaliculatum*, but it is nevertheless a sulcus, which is the most diagnostic feature of the genus *Coelogasteroceras*. If it can eventually be demonstrated that these physical differences among these specimens are only variations within a single taxon, then not only will all of them be retained in *Liroceras*, but also in *L. liratum*.

Occurrence.—6 specimens total; Brush Creek unit: 4 specimens, including holotype, from loc. PA: Aed-1; 1 specimen each from locs. Cma-3 and PA: Ash-1.

Repository.—Holotype, CM 25790; paratype, CM 25791; topotypes, SUI 7990A to 7990C; hypotype, USNM 161421.

Genus *Condraoceras* Miller, Lane & Unklesbay, 1947

Type species: *Condraoceras primum* Miller,
Lane & Unklesbay, 1947; OD

Condraoceras Miller, Lane & Unklesbay, 1947, p. 5; Kummel, 1964, p. K447, figs. 324, 4a, b; Windle, 1970, p. 104-105.

Diagnosis.—Large liroceratids having an equidimensional subcircular whorl section.

Description.—Conch large, sturdy, subdiscoidal, nautiliconic; W/D ratio approximately 0.50; umbilicus small, approximate U/D ratio 0.18; whorl section subcircular, H/W ratio 0.85± to 0.90, dorsum impressed about 0.30 of whorl height; sutures with shallow ventral and lateral lobes; siphuncle small, subcentral.

Remarks.—*Condraoceras* is morphologically similar to other liroceratid genera: *Coelogasteroceras* Hyatt, *Liroceras* Teichert, and *Peripetoceras* Hyatt. *Coelogasteroceras* can readily be recognized by its sulcate venter, and *Liroceras* by its depressed reniform whorl section. *Peripetoceras* is more like *Condraoceras* but can be identified by its more broadly flattened venter. The equidimensional subcircular whorl section of *Condraoceras* differs from each and all of the above related genera. According to published reports, specimens of *Condraoceras* are extremely rare. There are only two previously recorded occurrences, and these are widely separated geographically. Two specimens from the Upper Pennsylvanian Winterset Limestone in Jackson County, Missouri, are the types upon which Miller, Lane, and Unklesbay in 1947 established this genus and the species *C. primum*. Ruzhencev and Shimansky (1954, p. 129-130, pl. 12, figs. 4a-c) reported and described *C. ellipsoidale* from the Lower Permian (Artinskian) of the southern Urals; Shimansky (1967, p. 204) mentioned another unnamed species. We have a specimen of *C. primum* collected from the Cambridge limestone at New Concord in Muskingum County. We have another specimen questionably representing the genus from the Vanport unit at Bolivar in Tuscarawas County; this specimen is described separately.

Geologic range.—Pennsylvanian-Lower Permian.

Condraoceras primum Miller, Lane & Unklesbay, 1947
Pl. 1-45, figs. 1, 4

Condraoceras primum Miller, Lane & Unklesbay, 1947, p. 5, pl. 3, figs. 5, 6, pl. 4, figs. 1, 2; Kummel, 1964, p. K447, figs. 324, 4a, b; Windle, 1970, p. 105-107, pl. 3, figs. 12, 13.

Diagnosis.—Large liroceratids having a nearly circular whorl section.

Material.—*Condraoceras primum* is represented in our collection by a single well-preserved testiferous specimen consisting of the phragmocone and most of the body chamber, which occupies about half of the outer volution. This specimen, from the Cambridge limestone in the now-abandoned John Gress and Sons quarry near New Concord, Westland Township, Guernsey County, is the first positive record of the genus in Ohio and the second in North America (the other being Miller, Lane, and Unklesbay's specimen from Missouri). The margin near the aperture is somewhat broken and mashed, and the conch is mashed inward along the sides and venter at the boundary between the living chamber and the phragmocone. A small area of the phragmocone, approximately 18 by 30 mm, is partially exfoliated on the right side adjacent to the broken depressed area. The dimensions and ratios are: D = 115 mm, U (approximate) = 21 mm, H = 58 mm (not at adoral margin), W = 67 mm (not at adoral margin), W/D = 0.57, H/W = 0.87, U/D = 0.18. At the adoral margin of the body chamber the dorsum is impressed 20 mm, or approximately two-fifths of the whorl height, and the width of the impressed zone is 33 mm.

Description.—Conch large, nautiliconic; umbilicus small, steep walled, possibly slightly overhanging; deep interior of umbilicus concealed; whorl section subcircular to circular, circular near the apical margin of the ultimate volution (H/W ratio approximately 1.00) and subcircular near aperture (H/W ratio approximately 0.95); periphery of conch broadly and rather evenly convex, continuous curvature between venter and flanks; umbilical shoulders rounded and indistinct, umbilical wall abruptly rounded at dorsal seam. Test thick, 6 mm on flanks and 3 mm or less on dorsum and venter; outer surface not well preserved, but faint traces of indistinct growth lirae indicate a broad, moderately deep hyponomic sinus and a lateral salient. Septa and siphuncle not exposed, but Miller, Lane, and Unklesbay (1947, p. 5) observed and described those features on the types as follows:

> The camerae are moderate in length. Each suture forms a broad shallow broadly rounded ventral lobe and on either side of it a similar ventrolateral saddle, a somewhat deeper and broader lateral lobe, and a low umbilical saddle that extends to the rounded dorsal lobe. The siphuncle is small, at least at its passage through the septa and is subcentral in position.

Remarks.—Our Ohio specimen closely resembles the types of *Condraoceras primum*, which we have observed, and is certainly conspecific with them. *Condraoceras ellipsoidale* Ruzhencev & Shimansky (1954, p. 129-130, pl. 12, figs. 4a-c) from the Lower Permian (Artinskian) of the southern Urals is smaller, less rapidly expanded, and more distinctly reniform in whorl section than the North American specimens referred to *C. primum*.

Occurrence.—3 specimens total; Cambridge unit: 1 specimen from loc. Gwe-1; Winterset Limestone: 2 specimens from loc. MO: Jb-1.

Repository.—Holotype, KU 561; paratype, KU 562; hypotype, OSU 28833.

Condraoceras? sp.
Pl. 1-45, figs. 2, 3

Nautiloid undetermined Sturgeon, 1946, p. 35-36, pl. 8, fig. 5.

Diagnosis.—Large nautilicone having a fairly wide gradate umbilicus, equidimensional reniform whorl section, thick test, and eccentric dorsal siphuncle.

Material.—The only known specimen, a fragment of a large individual from the Vanport unit at Bolivar, Ohio, consists of approximately one-fourth whorl in each of three volutions. The outermost whorl remnant is testiferous over the umbilical wall and shoulder and on part of the flank; the intermediate whorl is shell covered over its umbilical surfaces; features of the innermost whorl are largely unknown because of distortion and incompleteness. Venter of the outermost whorl and right side of all whorls have been destroyed. Two approximate measurements and one ratio were determined on the intermediate whorl: H = 30 mm, W = 32 mm, H/W = 0.94.

Description.—Conch large, rapidly expanded, subglobose to subdiscoidal, nautiliconic; umbilicus moderate in size, deep, steep walled, but gradate with rounded, convex steps, nearly vertical on umbilical wall, but with an inward slope toward center of conch just above umbilical seam; this inward flare of the umbilical wall formed by a ridgelike thickening of the test; whorls reniform in cross section, maximum width below umbilical shoulders; intermediate whorl equidimensional in height and width, broadly rounded ventrally onto flanks, with no apparent boundary between venter and flanks, more narrowly rounded over umbilical shoulders, flattened laterally, and deeply impressed dorsally; outermost whorl definitely flattened on flanks, slightly convergent ventrally, sharply angular, nearly right angled internally at umbilical seams. Test very thick, apparently in several distinct layers, maximum thickness 6 mm in flanks, diminishing to 2 mm in umbilical walls; preserved surface ornament consisting of numerous fine transverse lirae extending slightly oblique orad on umbilical wall and swinging apicad across umbilical shoulder, not preserved farther. Septa in middle whorl about 4 mm apart, spaced at an approximate ratio of 1:7.5 to the whorl width; septa nearly transverse, more strongly arched apicad dorsoventrally than laterally; siphuncle located about one-third of distance between dorsal impressed zone and venter, but actually near center of overall cross section of whorl; siphuncle nearly circular at passage through a septum, apparently slightly higher than wide, diameter 3 mm at a whorl width of 32 mm, no further details available; suture pattern indistinct.

Remarks.—Restudy of this specimen has convinced us that it is a liroceratid and is possibly a representative of the genus *Condraoceras* Miller, Lane & Unklesbay. It is similar to their type species, *C. primum*, in size, in being an involute conch, and in having a similar H/W ratio, whorl section, thick test, and dorsal siphuncle. Our specimen differs in having a more compressed whorl profile and flattened flanks suggesting *Coelogasteroceras*, a deeper dorsal impressed zone, and a wider umbilicus. These differences, along with a different stratigraphic position, suggest a different species, even if it is a representative of *Condraoceras*. Its size, whorl profile, shell thickness, and wider umbilicus distinguish it from *Liroceras*. More and better material must be available before a definite decision can be made on generic and specific identities.

Occurrence.—1 specimen; Vanport unit: loc. Tl-1.

Repository.—OSU 18733.

Genus *Ephippioceras* Hyatt, 1884

Type species: *Nautilus ferratus* Cox, 1858; OD

Ephippioceras Hyatt, 1884, p. 290; Miller, Dunbar & Condra, 1933, p. 112-114; Miller & Youngquist, 1949, p. 129; Kummel, 1964, p. K448, fig. 326, 2; Gordon, 1964, p. 161-162; Windle, 1970, p. 107.

Diagnosis.—Ephippioceratids having connected, narrowly rounded, V-shaped dorsal and ventral saddles.

Description.—Conch medium sized, nautiliconic, subglobose, smooth or slightly costate, rapidly expanded; whorl section reniform, broadly rounded ventrally and laterally; umbilical shoulders rounded, impressed dorsally; umbilicus closed at maturity; sutures having narrowly rounded, V-shaped ventral saddle, broadly rounded lateral lobes, and rounded dorsal saddle; siphuncle small, subcentral, slightly dorsad.

Remarks.—*Ephippioceras* Hyatt resembles and presumably is closely related to *Megaglossoceras* Miller, Dunbar & Condra. The median ventral saddle of *Ephippioceras* is V-shaped and that of *Megaglossoceras* is tongue shaped. *Ephippioceras* is widespread in the Northern Hemisphere in strata from Mississippian to Early Permian in age; 10 or more species have been recognized. It is represented in both the Lower and Upper Carboniferous of Europe, and two species are reported from the Permian of China. In the United States, Pennsylvanian representatives occur from Pennsylvania to Texas, and Lower Permian examples occur in New Mexico and Texas. Specimens have been reported in Ohio from the Pottsville Group by Morningstar (1922, p. 272) and described and figured from the Allegheny Group by Sturgeon (1946, p. 18-19, pl. 4, figs. 2-4) and from the Conemaugh Group by Windle (1970, p. 108-110). Specimens also have been described and figured from the Conemaugh Group of western Pennsylvania by Miller and Unklesbay (1942b, p. 136, pl. 1, figs. 14, 15; 1947, p. 320, pl. l, figs. 7, 8).

Geologic range.—Mississippian-Permian.

Ephippioceras ferratum (Cox), 1858
Pl. 1-46, figs. 1-5, 7, 9

Nautilus ferratus Cox, 1858 (1857), p. 574-575, pl. 10, figs. 2, 2a.

E*phippioceras ferratum* Hyatt, 1884, p. 290; Miller, Dunbar & Condra, 1933, p. 114-118, pl. 3, figs. 14-17; Miller & Owen, 1934, p. 209-211, pl. 12, figs. 3, 4; figs. 1A, B; Sturgeon, 1937, p. 357; 1946, p. 12, 18-19, pl. 4, figs. 2-4; Miller & Unklesbay, 1942b, p. 136, pl. 1, figs. 14, 15; 1947, p. 320, pl. 1, figs. 7, 8; Miller, Lane & Unklesbay, 1947, p. 6, pl. 2, figs. 7-10; Unklesbay, 1962, p. 50-52, pl. 4, fig. 3; Gordon, 1964, p. 162-163, pl. 16, figs. 1-3, fig. 31; Windle, 1970, p. 108-110.

Ephippioceras sp. Morningstar?, 1922, p. 144, 272.

Diagnosis.—Medium-sized *Ephippioceras* having rapidly expanded whorls and rounded, subacute median ventral and dorsal saddles on each adult suture.

Material.—Twelve specimens of this ubiquitous but not abundant species are available for study. There is one specimen from the Lower Mercer unit of the Pottsville Group and another from the Cambridge unit of the Conemaugh Group; all others are from the Allegheny Group—five from the Columbiana unit, three from the Vanport unit, and two from the Putnam Hill unit. Morningstar (1922, p. 144, 272) reported a fragment of a very large *Ephippioceras* from the Lower Mercer unit of Muskingum County, but her specimen is no longer available. No specimen is complete, although one undistorted shell-bearing specimen (OSU 18708, pl. 1-46, fig. 3) from the Columbiana unit is nearly complete, and the other four from the same unit are likewise undistorted. The remaining specimens are fragmentary and mostly exfoliated, and several are also distorted. Maximum conch size is medium and includes three or more rapidly expanded whorls; the body chamber occupies about one-half whorl. The largest conch has a diameter of 56 mm and maximum width estimated at 50 mm. Another specimen has preserved subequal diameter and width of about 52 mm. Two smaller specimens have diameters of 27.5 and 30 mm, respectively.

Description.—Conch nautiliconic, subglobular, W/D ratios approximately 0.85 to 0.90; early whorls concealed but reported to be subcircular to subelliptical in cross section (Miller, Dunbar, and Condra, 1933, p. 114), mature whorls depressed, H/W ratios ranging from 0.55 to 0.65, reniform in outline, being broadly rounded from center of venter to umbilical shoulder, narrowly rounded or subangular across umbilical shoulder, slightly convex across dorsolateral surface, and impressed dorsally; maximum width in immature stage between umbilical shoulders, but between flanks in adult stage; impressed zone at least 8 mm deep and 12 mm wide; umbilicus deep with a tiny perforation about 1 mm long and 0.33 mm wide; umbilical wall steep and slightly convex. Test rather thin, ranging from 0.5 to 1 mm in thickness on largest specimen, thickest on flanks and in umbilical shoulders, smooth except for numerous, fine, sinuous growth lirae forming a slight convexity orad on flanks and a wide, rounded, moderately deep ventral sinus. Midventral longitudinal ridge on internal mold indicating presence of a conchal furrow. Septa rather closely spaced (2 to 4 mm apart on three immature specimens), moderately and evenly convex apicad, except for dorsoventral fold connecting dorsal and ventral saddles; sutures approximately transverse to long axis of conch, somewhat sinuous, forming a broad, rounded, and subacute ventral saddle bordered on each side by a broad, very shallow ventral lobe, a small rounded saddle at umbilical shoulder, a rounded and very shallow dorsolateral lobe, a small angular saddle at umbilical seam, and two rounded dorsal lobes flanking a median rounded dorsal saddle; siphuncle small, subcentral to slightly dorsal in position, orthochoanitic; septal necks short and straight, and connecting rings cylindrical (pl. 1-46, fig. 3).

Remarks.—In North America, *Ephippioceras ferratum* as now interpreted is a long-ranging and widespread species, occurring in Pennsylvanian strata from Atokan to Missourian in age, and is distributed geographically as far east as Pennsylvania, as far south as Arkansas and Missouri, and westward to Oklahoma in the Midcontinent region. Kindred species have been described from Asia and Europe. Although this species is long ranging and widespread, it is not abundant. Its occurrence in Ohio exemplifies its stratigraphic distribution elsewhere. One specimen and possibly a second one are from the Pottsville Group, 10 are from the Allegheny Group, and one is from the Conemaugh Group. This species seems to have been a stable one, as indicated by a remarkable degree of uniformity among known collections, and all North American Pennsylvanian representatives of *Ephippioceras* are referred with some doubt to the present species (Gordon, 1964, p. 163). Related species are known from the Lower and Upper Carboniferous of Europe and the Lower Permian of New Mexico and Texas.

Occurrence.—12 specimens total; Cambridge unit: 1 specimen from loc. Ls-1; Columbiana unit: 3 specimens from loc. Mg-7, 1 specimen each from locs. Cs-8 and Mg-10; Lower Mercer unit: 1 specimen from loc. CSj-1; Putnam Hill unit: 1 specimen each from locs. Mc-1 and Ms-3; Vanport unit: 2 specimens from loc. Mp-1, 1 specimen from loc. Vs-3.

Repository.—Hypotypes, OSU 18708, 18709, 18750, 28834 to 28836, 29149.

Genus *Megaglossoceras* Miller, Dunbar & Condra, 1933

Type species: *Nautilus montgomeryensis* Worthen, 1884; OD

Megaglossoceras Miller, Dunbar & Condra, 1933, p. 118-119; Miller & Owen, 1934, p. 211-214; figs. 1C, D; Kummel, 1964, p. K448, fig. 326, 1; Gordon, 1964, p. 163; Windle, 1970, p. 110-111.

Diagnosis.—Similar to *Ephippioceras* but differing in having a broader conch, more angular umbilical shoulders, and a linguloid ventral saddle.

Description.—Gordon (1964, p. 163) summarized the salient features of the genus as follows:

> Conch nautiliconic, globose to subglobose, width usually greater than diameter in adult. Whorl depressed, with rounded to flattened venter; flanks steepening gradually. Umbilicus of moderate size; umbilical shoulders subangular to rounded. Suture with tongue- or V-shaped ventral saddle produced apicad.

To these details can be added that the siphuncle is small, subcentral, and presumably orthochoanitic.

Remarks.—Gordon (1964, p. 163) noted the possibility of V-shaped median ventral saddles and rounded umbilical shoulders among certain species assigned to *Megaglossoceras*, even though both features are considered to be diagnostic features of *Ephippioceras*. He further noted that as additional species have been recognized, it has become more difficult to separate these two genera and that it may eventually be feasible to include all species referred to these two genera in a single genus, *Ephippioceras*. He concluded, however, that placing all known species in one genus is not presently warranted. *Megaglossoceras* is less abundant and less widespread than *Ephippioceras*. Gordon (1964, p. 163) listed a total of six species in *Megaglossoceras*, but did not include *M. pristinum* Miller & Owen, which was probably inadvertently omitted. Also, Gordon's spelling of the specific name of the type species as "montgomereyensis," adding an "e" between the "r" and the "y," must have been an error, although he used that spelling several times. Only one of Gordon's species, *M. kansuense* Liang from the Carboniferous of northern China, is known outside the Pennsylvanian of the central United States. American species have been reported from Arkansas, Colorado, Kansas, Missouri, and Nebraska; in addition, Miller and Unklesbay (1942b, p. 137, pl. 1, fig. 16) described a mere fragment from the Conemaugh Group of western Pennsylvania. To these occurrences we add five fragmentary specimens from eastern Ohio.

Geologic range.—Pennsylvanian.

Megaglossoceras spp.
Pl. 1-46, figs. 8, 10-12

Megaglossoceras sp. Miller & Unklesbay, 1942b, p. 137, pl. 1, fig. 16; Windle, 1970, p. 111-112, pl. 3, fig. 14.

Diagnosis.—*Megaglossoceras* having shallow to moderately deep, broad, widely diverging, tongue-shaped, median ventral saddles.

Material.—Except for Windle's citation, no previous recognition of *Megaglossoceras* specimens from Pennsylvanian rocks of Ohio has been made, unless Morningstar's (1922, p. 272) specimen of *Ephippioceras* sp. from the Lower Mercer limestone of Muskingum County is an example. We have five fragmentary specimens available from Ohio, three from the Brush Creek unit and one each from the Putnam Hill and Vanport units. One Brush Creek specimen has unfortunately almost completely disintegrated. Another Brush Creek specimen (OSU 28837) and the Putnam Hill specimen (OSU 28839) have preserved only small portions of the midventral region showing the pattern of the saddles (pl. 1-46, figs. 11, 12). This Brush Creek specimen also has the only remnant of preserved test on any of our specimens. The remaining Brush Creek specimen (OSU 28838, pl. 1-46, fig. 8) and the Vanport specimen (OSU 28840, pl.1-46, fig. 10) have larger areas of the ventral region showing patterns of the midventral saddle in five to six sutures; specimen OSU 28838 has a small portion of the body chamber and possibly a short amount of the ventromyarian area and line. Approximate preserved dimensions of specimen OSU 28838 (Brush Creek) are: length = 73 mm and width = 60 mm; those for specimen OSU 28840 (Vanport) are: length = 58 mm and width = 50 mm. These measurements apply only to the sizes of the fragments and provide no reliable figures to the overall sizes of the specimens.

Description.—The oldest specimen (OSU 28839), a mere fragment from the Putnam Hill unit showing a very limited median ventral area with tiny remnants of three septa and adjacent camerae, is only tentatively referred to *Megaglossoceras* and may be a piece of a large *Ephippioceras*. The only indications for assignment to *Megaglossoceras* are a flattened venter and shallow, rounded, flaring saddles (pl. 1-46, fig. 11). The flattened venter and shallow midventral saddles suggest *M. magnum* Miller, Dunbar & Condra (1933, p. 122, figs. 20A, B), but more complete specimens will be necessary before a meaningful comparison can be made.

The specimen (OSU 28840) from the Vanport limestone has preserved a portion of the venter with limited parts of five sutures and adjacent camerae (pl. 1-46, fig. 10). This specimen differs from the others in having a rounded venter. The ventral saddles are broadly rounded, more tongue shaped, and deeper than those of the Putnam Hill specimen, and they more nearly resemble those of the Brush Creek specimens. A tiny and inconspicuous longitudinal ridge indicates a very small conchal furrow on the interior of the shell. The rounded venter recommends comparison with *M. glicki* Gordon (1964, pl. 14, figs. 1, 2) from the Atokan of Arkansas. Gordon's species, represented by a much larger specimen, appears to have shallower and more divergent ventral saddles. Our specimen, however, seems to be more comparable with *M. pristinum* Miller & Owen (1934, pl. 12, figs. 1, 2; figs. 1C, D) from the Cherokee Formation of Missouri; the size and midventral saddles are almost identical, but do differ in ventral roundness of the whorl, which is more narrowly rounded in their species. More entire specimens will be needed for more certain comparisons.

One of the Brush Creek specimens (OSU 28838) is our largest (dimensions given in section on Material). It consists of a partial ventral mold, possibly with shallow transverse constrictions, of a small part of the venter, comprising the adoral six septa of the phragmocone and a small portion of the body chamber (pl. 1-46, fig. 8). A second Brush Creek specimen (OSU 28837) is a small fragment of the venter showing small amounts of three septa and adjacent areas with a partial area covered by shell (pl. 1-46, fig. 12). If the limited evidence from these fragments is reliable, all the Brush Creek specimens have broad, flattened venters, and their midventral saddles are similar in being rounded, deep, divergent, and tongue shaped (pl. 1-46, figs. 8, 12). Windle (1970, p. 112) noted that the sutures of our largest specimen are similar to those of *Megaglossoceras montgomeryense* (Worthen) and *M. glicki* Gordon (1964, pl. 14, figs. 1, 2); Miller and Unklesbay (1942b, p. 137) also compared the suture of a Brush Creek specimen from western Pennsylvania with those of Worthen's species. Those authors stated that satisfactory comparisons are not possible for definite identification of species; that statement applies equally well to our specimens.

Remarks.—In spite of the limited preservation of the Ohio specimens and our inability to identify them specifically with any degree of certainty, it is possible that as many as three species may be represented. One specimen, which possibly may be an *Ephippioceras*, has a flat venter and deep, rounded, tongue-shaped, divergent midventral saddles. A second species is more certainly a *Megaglossoceras* but also has a flat venter and deep, rounded, tongue-shaped, divergent midventral saddles. A third species has a rounded venter but is also characterized by deep, rounded, tongue- shaped, divergent midventral saddles.

Occurrence.—5 specimens total; Brush Creek unit: 1 specimen each from locs. Aa-41, Aw-51, and Cfr-1; Putnam Hill unit: 1 specimen from loc. Mc-2; Vanport unit: 1 specimen from loc. Mp-1.

Repository.—OSU 28837 to 28840.

Genus indeterminate #1 sp.
Pl. 1-47, figs. 2, 3

Diagnosis.—Medium-sized to large, apparently tarphyceraconic conch having a flattened but convex venter, flattened to slightly convex flanks, possibly elongate ventrolateral nodes, and widely spaced sutures forming prominent, broadly rounded ventrolateral saddle and lateral lobes.

Material.—There is only a single, somewhat distorted, exfoliated, fragmentary, immature specimen consisting of part of the phragmocone and the apicad end of the body chamber. Only limited measurements of conch and whorl could be determined.

Description.—Conch medium sized to large, apparently tarphyceraconic, subglobose; size of umbilicus uncertain; whorl depressed, venter flattened but apparently slightly convex; flanks wide, flattened, also slightly convex; umbilical walls rather narrow, steep, a little convex; dorsal impressed zone approximately 25 mm wide, depth unknown; ventrolateral and umbilical shoulders broadly rounded, the former distorted by mashing, apparently bearing widely spaced, indistinct, elongate nodes. Septa rather widely spaced, extended farther orad ventrally, 16 to 18 mm apart along venter, narrowing to 6 mm on umbilical walls; sutures sinuous, forming a large, very broadly rounded ventral saddle, asymmetrical rounded lateral lobes, and a nearly straight course across the umbilical wall; other details of septa and sutures and all details of siphuncle unknown.

Remarks.—Incompleteness and distortion of this specimen makes generic and specific identification impossible. Consideration was given to the genera *Endolobus*, *Liroceras*, *Metacoceras*, and *Stearoceras*. Each of these genera was rejected because of uncertainties and differences in suture patterns, ventrolateral nodes, and whorl sections.

Occurrence.—1 specimen; Putnam Hill unit: loc. Vel-15.

Repository.—OSU 28969.

Genus indeterminate #2 sp.
Pl. 1-47, fig. 1

Stenopoceras smithi? Windle, 1970, p. 89 (in part).

Diagnosis.—Large nautiliconic conchs having a small funnel-shaped umbilicus, rounded umbilical shoulders, convex or flattened flanks, and broadly rounded venter with transverse corrugations on ventrolateral portions of the outer whorl.

Material.—Two large, fragmentary, somewhat distorted specimens consisting of ventral and lateral portions of the outer whorl were collected from the Brush Creek and Putnam Hill units and are the only available examples. The larger one has preserved part of the venter of the body chamber and is represented by both external and internal molds and a considerable amount of fragmented shell material. This specimen (OSU 28862) is approximately 185 mm long and 142 mm wide and has a convexity of about 45 mm and an estimated conch diameter approaching 200 mm. The smaller specimen (OSU 29309) is a somewhat distorted and largely test-covered left side showing a narrow and deep umbilicus. It is estimated to have a conch diameter of at least 100 mm, and its inner umbilical diameter is approximately 8 mm.

Description.—Conch large, nautiliconic, apparently deeply involute; umbilicus small, deep, and infundibular; whorl section depressed, presumably reniform, with rounded or flattened flanks, broadly rounded venter, and rounded ventrolateral and umbilical shoulders; lower flanks and venter bearing low, wide, rounded, somewhat irregular corrugations spaced approximately 12 mm apart on the smaller specimen and up to 20 mm apart on the larger one, separated by narrower rounded troughs and extended obliquely apicad upward and ventrad downward across flanks and onto venter. Test moderately thick, somewhat thicker in flanks than on venter and umbilical walls of preserved portions, 1 to 1.5 mm thick on the smaller specimen and 2 mm thick on the larger one, much weathered and chalky white, apparently in two or more layers on the larger one; surface ornament not well preserved, but indistinct growth lines consisting of fine striae separated by wider flat-topped bands, showing a very shallow and widely rounded ventral sinus, broadly rounded lateral salients, and a nearly straight course across umbilical wall. Other features of test and phragmocone not preserved.

Remarks.—General form and discernible growth lines showing a shallow hyponomic sinus indicate that these specimens are nautiloid cephalopods. Their size and shape suggest that they represent the genus *Solenochilus*, and their oblique transverse corrugations, which are presumed to be original, hint of a possible relationship to *S. cambridgensis* Frontz. These possibilities are rejected, however, because the specimens have rounded instead of angular carinate umbilical shoulders. The corrugations, the shallow hyponomic sinus, and possibly the amount of involution prevent their assignment to the genus *Stearoceras*. Their incompleteness and distortion prevent any generic assignment at present.

Occurrence.—2 specimens total; Brush Creek unit; 1 specimen from loc. Aa-41; Putnam Hill unit: 1 specimen from loc. Vel-15.

Repository.—OSU 28862, 29309.

Genus *Ctenobactrites* Shimansky, 1951

Type species: *Ctenobactrites costatus* Shimansky, 1951; OD

Ctenobactrites Shimansky, 1951, p. 867; 1954, p. 80-91; 1962, p. 237; 1968, p. 119-120; Erben, 1964, p. K501, fig. 358, 4; Mapes, 1979, p. 49; Sturgeon, Windle, Mapes & Hoare, 1982, p. 1472-1473.

Diagnosis.—Similar to *Bactrites* in having an orthoconic conch that is circular to broadly oval in cross section and having almost straight sutures with a small V-shaped ventral lobe, but differing from that genus in possessing surface ornament of simple transverse bands or ridges.

Remarks.—Mapes (1979, p. 49) reviewed the species assigned to this genus and the problems remaining to be resolved. Except for surface ornament, conchs of *Ctenobactrites* are morphologically like those of *Bactrites*. *Bactrites* normally has either a smooth or longitudinally ornamented test on the phragmocone and *Ctenobactrites* has a more or less pronounced transverse ornament in the form of coarse ridges or bands.

In North America, Pennsylvanian representatives of *Ctenobactrites* are extremely rare. In one of the early reports of bactritoids of North America, Miller and Unklesbay (1947, p. 324-325) described a fragmentary orthoconic conch from the Brush Creek limestone in western Pennsylvania as *Bactrites*? *collinsi*. Mapes (1979, p. 49-50) reassigned this taxon to *Ctenobactrites* on the basis of a single coarsely banded patch of test adhering to their specimen. Mapes (1979, p. 49) also described but did not specifically name an incomplete phragmocone from the Finis Shale Member of the Graham Formation of Texas. In the article by Sturgeon, Windle, Mapes, and Hoare (1982, p. 1473) several specimens of *Ctenobactrites isogramma* from the Pennsylvanian of eastern Ohio were described, and the specimen originally described by Meek (1871b, p. 172-173) as *Orthoceras*? *isogramma* was shown to be in fact a *Ctenobactrites*. Furthermore, ontogenetic reconstruction of the conch of *C. isogramma* requires suppression of *C. collinsi* (Miller & Unklesbay) as a junior synonym of that species.

Geologic range.—Mississippian-Permian.

Ctenobactrites isogramma (Meek), 1871

Pl. 1-1, figs. 8-11, 14; pl. 1-42, fig. 3

Orthoceras? *isogramma* Meek, 1871b, p. 172-173.
Orthoceras isogramma Morningstar, 1922, p. 266-267, pl. 16, figs. 5, 6.
Bactrites? *collinsi* Miller & Unklesbay, 1947, p. 324-325, pl. 1, figs. 1, 2.
Ctenobactrites collinsi Mapes, 1979, p. 49-50, pl. 33, figs. 1-3.
Ctenobactrites isogramma Sturgeon, Windle, Mapes & Hoare, 1982, p. 1473, pl. 1, figs. 2, 3, 7; pl. 2, figs. 1-3.

Diagnosis.—*Ctenobactrites* possessing coarse transverse striae in early ontogeny and changing to wide asymmetrical bands in late ontogenetic stages.

Material.—This species is represented in our Ohio collections by two partially test-covered body chambers with terminal septa; two crushed incomplete phragmocones, one with ornament; two fragments of test with the diagnostic ornament; and several fragments of molds and tests.

Description.—Longiconic conch having an apical angle between 6° and 12° and early ontogenetic ornament at an estimated conch diameter of 3.8 mm, consisting of coarse, transverse lirae (10-14 per mm), stronger lirae 8 to 10 mm apart; ornament slightly sinuous and inclined somewhat dorsad, becoming broadly banded at an estimated conch diameter of 5.4 mm and rapidly evolving into nearly imbricate asymmetrical bands or ridges separated by cuestalike grooves having a band width of 2 mm at a maximum conch diameter of 43 mm.

Remarks.—Inquiries to likely repositories failed to locate Meek's holotype of *Ctenobactrites isogramma*. The specimen came from the lower Pennsylvanian near Newark, Ohio, and Morningstar (1922, p. 147, 267) suggested that it probably came from the Lower Mercer unit at Bald Knob, about 2 miles southeast of Newark. Her specimen (OSU 4710, pl. 1-1, fig. 8) from the Lower Mercer near Flint Ridge is available as a neotype (neolectotype), if the holotype cannot be found.

Occurrence.—14 specimens total; Columbiana unit: 1 specimen from loc. Msp-1; Lower Mercer unit: 2 specimens from loc. LIho-1, 1 specimen each from locs. LIho-3 and LIm-1; Putnam Hill unit: 2 specimens from loc. Ty-3, 1 specimen each from locs. Me-1, Me-3, MUho-9, and Vel-15; Upper Mercer unit: 1 specimen from loc. CSje-1; Vanport unit: 1 specimen from loc. Vel-20; Washingtonville unit: 1 specimen from loc. CAr-2.

Repository.—Hypotypes, OSU 4710, 15239, 15240, 28801 to 28805.

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APPENDIX A.—NAUTILOID AND BACTRITOID COLLECTING LOCALITIES

Specimens providing the basis for this report on nautiloids and bactritoids were collected from 15 stratigraphic units at 139 localities in 21 Ohio counties, nine stratigraphic units at 24 out-of-state localities, and two stratigraphic units at two foreign localities. The Ohio localities are in Athens, Carroll, Columbiana, Coshocton, Guernsey, Hocking, Holmes, Jackson, Jefferson, Lawrence, Licking, Mahoning, Meigs, Muskingum, Noble, Perry, Scioto, Stark, Summit, Tuscarawas, and Vinton Counties (see fig. 1-1, p. 1). Localities outside Ohio are in Illinois, Kansas, Maryland, Missouri, Nebraska, Pennsylvania, West Virginia, England, and Ireland.

Ohio localities are listed in numerical order under their respective counties and civil townships, which are arranged alphabetically according to county and township names. The capitalized first letter(s) of the locality designation indicates the county, the lower case letter(s) the civil township, and the number following is our file number for that particular locality in that township. Exposures are located by sections or fractions thereof, by reference to natural features or cultural landmarks present at the time of collecting, and/or by reference to nearby elevation numbers on pertinent U.S. Geological Survey 7.5-minute topographic quadrangle maps, which are indicated in capital letters. This information is followed by the name of the stratigraphic unit(s); the file number(s) of any Ohio Division of Geological Survey (OGS) stratigraphic section(s) at or near the locality; the names of identified species and, in parentheses, the number of specimens collected at that locality. It should be noted that most mine localities have been reclaimed and are no longer accessible for collecting. Other localities also may be inaccessible.

For out-of-state localities, capital letters indicate the state and the county, separated by a colon; the lower case letter(s) indicates the civil township or its equivalent; and the number following is our file number. A brief description of the site is given, followed by the name of the U.S. Geological Survey 7.5-minute topographic quadrangle map in capital letters, the stratigraphic unit, the names of identified species and, in parentheses, the number of specimens of that species collected at that locality. The foreign locality descriptions are similarly arranged.

(Editor's note: some descriptions may now be out of date because of road and other cultural changes.)

OHIO LOCALITIES

ATHENS COUNTY:

Alexander Township:

Aal-41. Exposures along U.S. Rte. 50 approx. 0.5 mile (0.8 km) Southwest of Alexander Church, THE PLAINS. Ames. *Brachycycloceras* sp. (1).

Athens Township:

Aa-12. Exposure on east-northeast side of Columbus Rd. (former U.S. Rte. 33), extending from former Workingman's Friend gasoline station uphill to Columbia Ave. behind State Highway Patrol post at north edge of Athens, ATHENS. Portersville. OGS 11434. *Pseudorthoceras knoxense* (4), *Metacoceras mcchesneyi* (2).

Aa-27. Exposure in ravine on south side of Ohio Rte. 682 and Hocking River on Athens Mental Health Center grounds, ATHENS. Ames. OGS 11235. *Metacoceras mcchesneyi*? (1).

Aa-41. Exposure at cliff on east side of Ohio Rte. 56, 0.4 mile (0.65 km) south of junction of Ohio Rtes. 56 and 682, THE PLAINS. Brush Creek. OGS 12158. *Thoracoceras*? sp. (3), *Brachycycloceras* sp. (4), *Pseudorthoceras knoxense* (95), *Metacoceras clinocostatum* (102), *M. latum* (1), *M. mcchesneyi* (35), *Domatoceras* cf. *D. highlandense* (1), *Stenodomatoceras gardi*? (1), *Solenochilus johnstoni*? (2), *Liroceras liratum* (53), *Megaglossoceras* sp. (1), Genus indeterminate #2 sp. (1).

Aa-47. Exposure in ravine on east side of U.S. Rtes. 33 and 50 bypass between Athens Twp. Rd. 402 (Hooper Rd.) and Athens County Rd. 25 (Rock Riffle Rd.), ATHENS. Ames. *Tainoceras* sp. #1 (1).

Aa-53. Exposure (now graded over and built upon) on south side of Ohio Rte. 56 approx. 0.75 mile (1.2 km) Southwest of junction of Ohio Rtes. 56 and 682, THE PLAINS. Brush Creek. *Metacoceras clinocostatum* (3).

Aa-58. Exposure at 103 West Washington St., Athens, ATHENS. Ames. *Domatoceras* cf. *D. highlandense* (1).

Aa-59. Undescribed exposure on south side of West Branch Margaret Creek and east of intersection of County Rds. 10 and 79 at elevation 665, THE PLAINS. Ames. *Mooreoceras normale* (1).

Dover Township:

Ad-4. Exposures along ravine west of Dover Twp. Rd. 295 (Utah Ridge Rd.), W-ctr. sec. 35, NELSONVILLE. Brush Creek. OGS 6718. *Pseudorthoceras knoxense* (2).

Ad-13. Exposure on north side of tributary valley to Big Bailey Run, NW$^{1}/_{4}$NE$^{1}/_{4}$ sec. 35, NELSONVILLE. Ames. OGS 11493. *Tainoceras* sp. #2 (1).

Ad-32. Exposure along valley and tributary valley, sec. 15, JACKSONVILLE. Brush Creek. OGS 11462. *Metacoceras clinocostatum* (1), *Metacoceras* sp. #2 (1).

Lee Township:

Ale-18. Diamond Stone Quarries, Inc., Plant No. 2 on north side of U.S. Rte. 50, NW$^{1}/_{4}$ sec. 13 and SW$^{1}/_{4}$ sec. 14, ALBANY. Brush Creek. OGS 11559. *Pseudorthoceras knoxense* (6), *Liroceras liratum* (1).

Ale-33. Abandoned quarry, NE$^{1}/_{4}$NE$^{1}/_{4}$ sec. 13, ALBANY. Brush Creek. *Solenochilus johnstoni* (1).

Ale 35. Exposures along Ohio Rte. 32 (formerly Ohio Rte. 346) (Appalachian Hwy.), secs. 13 and 19, ALBANY and VALES MILLS. Brush Creek. *Pseudorthoceras knoxense* (3), *Mooreoceras normale* (4), *Metacoceras* sp. #1 (2), *Liroceras liratum* (10).

Trimble Township:

At-67. Exposure at an undescribed location near Trimble, sec. 8, JACKSONVILLE. Ames. *Stenopoceras smithi* (2).

Waterloo Township:

Aw-48. Exposure along ravine in N$^{1}/_{2}$SW$^{1}/_{4}$ sec. 3, THE PLAINS. Brush Creek. OGS 7618. *Pseudorthoceras knoxense* (1).

Aw-51. Exposures in ravines in NW$^{1}/_{4}$NW$^{1}/_{4}$ sec. 1 and NE$^{1}/_{4}$NE$^{1}/_{4}$ sec. 7, THE PLAINS. OGS 7621. Brush Creek. *Metacoceras clinocostatum* (5), *Solenochilus mcfarlandi*? (3), *Megaglossoceras* sp. (1).

York Township:

Ay-11. Exposure along Athens County Rd. 73 on south side of Hocking River valley, NW$^1/_4$NW$^1/_4$ sec. 23, NELSONVILLE. Dorr Run. OGS 6733. *Metacoceras* sp. (1).

CARROLL COUNTY:

Rose Township:

CAr-2. Strip mines of James Bros. Coal Co. south of Huff Run, secs. 32 and 33, MINERAL CITY. Washingtonville. OGS 15098. *Pseudorthoceras knoxense* (50), *Mooreoceras normale* (8), *Metacoceras latum* (28), *Temnocheilus annulonodosus* (1), *Latitemnocheilus*? sp. #1 (1), *Domatoceras oreskovichi* (3), *D. shepherdi* (2), *Liroceras liratum* (1), *Ctenobactrites isogramma* (1).

COLUMBIANA COUNTY:

Center Township:

Cc-2. Exposure on east side of Middle Fork Little Beaver Creek, NW$^1/_4$ sec. 14, LISBON. Washingtonville. *Pseudorthoceras knoxense* (2).

Cc-4. Exposures in vicinity of former Excelsior Fire Clay Co. plant and along Ohio Rte. 164 south of Middle Fork Little Beaver Creek at the Southwest edge of Lisbon, E$^1/_2$NW$^1/_4$ sec. 23, LISBON. Washingtonville. OGS 5262. *Pseudorthoceras knoxense* (2).

Elkrun Township:

Cer-3. Exposure along Middle Run, NW$^1/_4$NE$^1/_4$ sec. 20, ELKTON. Vanport. OGS 1681. *Brachycycloceras* sp. (1).

Fairfield Township:

Cf-1. Abandoned strip mine southeast and Southwest of East Branch of Middle Fork Little Beaver Creek and junction with small north-flowing tributary, SE$^1/_4$ sec. 7, COLUMBIANA or ELKTON. Washingtonville. *Pseudorthoceras knoxense* (1).

Franklin Township:

Cfr-1. Exposure in Conrail RR cut at south edge of Summitville just east of Ohio Rte. 644, NW$^1/_4$SE$^1/_4$ sec. 23, KENSINGTON. Brush Creek. OGS 14776. *Pseudorthoceras knoxense* (8), *Metacoceras clinocostatum* (3), *Megaglossoceras* sp. (1).

Madison Township:

Cma-3. Abandoned strip mines on north side of Columbiana County Rd. 424, sec. 23, WEST POINT. Brush Creek. *Brachycycloceras* sp. (1), *Pseudorthoceras knoxense* (135), *Mooreoceras normale* (78), *M. tuba* (1), *Poterioceras curtum* (1), *Metacoceras mcchesneyi* (300+), *Metacoceras* sp. #1 (1), *Stenodomatoceras gardi* (44), *Solenochilus mcfarlandi* (9), *Liroceras liratum* (1), *Coelogasteroceras dubium* (1).

Cma-5. Abandoned strip mine on Harry Given farm on Southwest side of Columbiana County Rd. 424, NE$^1/_4$SW$^1/_4$ sec. 23, WEST POINT. Brush Creek. *Brachycycloceras* sp. (2).

Cma-9. Abandoned strip mine on Earl Reed farm, E-ctr. SE$^1/_4$ sec. 27, WEST POINT. Brush Creek. *Domatoceras* sp. (1).

Perry Township:

Cp-1. Exposure along second ravine south of Perry Twp. Rd. 852 (Painter Rd.) approx. 0.25 mile (0.4 km) west of Perry Twp. Rd. 766 (Egypt Rd.), SE$^1/_4$NE$^1/_4$ sec. 32, SALEM. Columbiana. *Temnocheilus annulonodosus* (1).

Cp-3. Exposure at abandoned Brookwood mine (type locality for Columbiana shale) east of U.S. Rte. 62 and west of Perry Twp. Rd. 766 (Egypt Rd.), SE$^1/_4$NW$^1/_4$ sec. 29, SALEM. Columbiana. OGS 3778. *Brachycycloceras* sp. (1), *Pseudorthoceras knoxense* (19), *Mooreoceras normale* (1), *Metacoceras perelegans* (3), *Domatoceras obsoletum* (1), *Solenochilus greenensis* (1), *Liroceras liratum* (4).

Salem Township:

Cs-3. Spoil pile (now removed) of abandoned Delmore mine of Sterling Coal Co. on valley floor of East Branch of Middle Fork Little Beaver Creek northeast of Franklin Square and north of Ohio Rte. 344, NE$^1/_4$SW$^1/_4$ sec. 14, LISBON. Columbiana. OGS 1707. *Brachycycloceras* sp. (4), *Pseudorthoceras knoxense* (1), *Mooreoceras normale* (1), *Metacoceras perelegans* (1), *Liroceras liratum* (2).

Cs-5. Abandoned J. Fox and Howell Bros. mine on east side of Cherry Valley Run east of abandoned Y & O RR bridge, SE$^1/_4$SE$^1/_4$ sec. 1, SALEM. Washingtonville. OGS 3784. *Liroceras liratum* (1).

Cs-7. Spoil banks of abandoned Bossart or Buzzards Glory mine on west side of Middle Fork Little Beaver Creek, SW$^1/_4$NE$^1/_4$ sec. 3, SALEM. Columbiana. *Temnocheilus annulonodosus* (1), *Liroceras liratum* (1).

Cs-8. Spoil banks of abandoned McKeefry shaft mine on west side of Middle Fork Little Beaver Creek, N ctr. sec. 15, LISBON. Columbiana. OGS 1901. *Metacoceras perelegans* (1), *Ephippioceras ferratum* (1).

Cs-9. Spoil banks of abandoned shaft mines along Middle Fork Little Beaver Creek near Teegarden, NE$^1/_4$ sec. 32, LISBON. Columbiana. *Mooreoceras normale* (2).

Cs-14. Exposure at entrance to abandoned drift mine (now stripped) on east side of Cherry Valley Run and on south side of Alt. Ohio Rte. 14 at east edge of Washingtonville, NE$^1/_4$NW$^1/_4$ sec. 1, SALEM. Washingtonville. *Domatoceras shepherdi* (1).

St. Clair Township:

Csc-1. Exposures along Bieler Run, N$^1/_2$ sec. 12, EAST LIVERPOOL NORTH. Vanport. OGS 2019. *Brachycycloceras* sp. (1), *Brachycycloceras*? cf. *B.*? *spectrum* (1).

Uncertain localities:

Cuc-1. Undescribed location. Columbiana. *Solenochilus greenensis* (1).

Cuc-2. Undescribed location. Columbiana. *Liroceras liratum* (2).

Cuc-3. Undescribed location. Columbiana. *Mooreoceras normale* (3).

Cuc-4. Undescribed location. Columbiana. *Temnocheilus annulonodosus* (3).

COSHOCTON COUNTY:

Clark Township:

CScl-1. Undescribed location near Blissfield?, KILLBUCK. Lower Mercer? *Domatoceras williamsi* (1).

Franklin Township:

CSf-1. Spoil banks of abandoned underground mine of Best Coal Co. on east side of Muskingum River east of Conesville, CONESVILLE. Washingtonville. OGS 11878. *Metacoceras latum* (2).

Jackson Township:

CSj-1. Abandoned borrow pit approx. 200 feet (65 meters) west of Ohio Rte. 16 and 0.5 mile (0.8 km) south of Ohio Rte. 541, RANDLE. Lower Mercer. *Ephippioceras ferratum* (1).

Jefferson Township:

CSje-1. Exposure on Wheeler farm along slope of ridge east of Jefferson Twp. Rd. 59 approx. 1.0 mile (1.6 km) east of and 1.0 mile (1.6 km) north of Mohawk Village, WARSAW. Upper Mercer. *Ctenobactrites isogramma* (1).

Virginia Township:

CSv-1. Abandoned strip mine of Adams Mills Coal Co., NE$^1/_4$NW$^1/_4$ sec. 17, CONESVILLE. Washingtonville. OGS 6775. *Mooreoceras tuba* (5), *Metacoceras latum* (4).

CSv-3. Abandoned strip mines in SW$^{1}/_{4}$ sec. 17, CONESVILLE. Washingtonville. *Pseudorthoceras knoxense* (9).

CSv-4. Exposures along Coshocton County Rd. 6 and in prospect pits along Mill Fork in vicinity of Peabody Coal Co. at end of N & W RR spur, secs. 3, 8, and 9, CONESVILLE. Washingtonville. *Mooreoceras tuba* (2), *Metacoceras latum* (4).

GUERNSEY COUNTY:

Westland Township:

Gwe-1. Abandoned quarry of John Gress and Sons (later Ace Landfill) approx. 0.25 mile (0.4 km) east of New Concord and 0.3 mile (0.5 km) north of U.S. Rte. 40, NEW CONCORD. Cambridge. Metacoceras clinocostatum (1), *Domatoceras* cf. *D. highlandense* (1), *Solenochilus cambridgensis* (4), *Condraoceras primum* (1).

Gwe-2. Abandoned strip mine in SE$^{1}/_{4}$ sec. 19 and NE$^{1}/_{4}$ sec. 22, NEW CONCORD. Cambridge and Portersville. *Pseudorthoceras knoxense* (Cambridge, 8; Portersville, 4).

HOCKING COUNTY:

Falls Gore Township:

Hfg-5. Abandoned strip mines of Hocking Valley Brick Co. on south side of Falls Gore Twp. Rd. 343 (Geiger Rd.), SE$^{1}/_{4}$ sec. 31, GORE. Lower Mercer. OGS 7070. *Pseudorthoceras knoxense* (27), *Mooreoceras normale* (1), *Latitemnocheilus* cf. *L. johnsoni* (1), *Solenochilus peculiare* (1).

Green Township:

Hg-6. Abandoned strip mine of Logan Clay Products Co., E$^{1}/_{2}$ sec. 36 (Morningstar's locality 86), GORE. Putnam Hill. *Liroceras liratum* (1).

Ward Township:

Hw-16. Undescribed locality near Carbon Hill, NELSONVILLE? Putnam Hill. *Pseudorthoceras knoxense* (120), *Metacoceras* sp. #2 (3), *Endolobus* cf. *E. forbesianus* (1), *Temnocheilus annulonodosus* (11).

HOLMES COUNTY:

Clark Township:

HOc-3. Abandoned strip mine along Ohio Rte. 93 on northeast corner of road junction at elevation 1014 approx. 1.0 mile (1.6 km) northeast of Baltic, NE$^{1}/_{4}$NE$^{1}/_{4}$ sec. 25, BALTIC. Putnam Hill. *Michelinoceras*? *unicamera* (1), *Pseudorthoceras knoxense* (1).

Hardy and Berlin Townships:

HOh-1. Quarry of Holmes Limestone Co., W$^{1}/_{2}$ sec. 3, Hardy Twp., and E$^{1}/_{2}$ sec. 4, Berlin Twp., BERLIN. Putnam Hill. *Latitemnocheilus* cf. *L. johnsoni* (1).

JACKSON COUNTY:

Jefferson Township:

Jje-2. Exposure near Monroe Furnace, N$^{1}/_{2}$ sec. 29 (Morningstar's locality 80). PETERSBURG. Putnam Hill. *Liroceras liratum* (1).

Milton Township:

Jmi-2. Exposure on north side of Jackson County Rd. 58 (Buckeye Furnace Rd.) along Buffer Run, SW$^{1}/_{4}$SE$^{1}/_{4}$ sec. 24, MULGA. Vanport. *Pseudorthoceras knoxense* (20).

Jmi-3. Mine 10 of Superior Cement Co., NW$^{1}/_{4}$ sec. 13, MULGA. Vanport. *Domatoceras williamsi* (1).

JEFFERSON COUNTY:

Saline Township:

JEsa-2. Exposure at McClain Firebrick Co. approx. 1.0 mile (1.6 km) southeast of Irondale, SW$^{1}/_{4}$NW$^{1}/_{4}$ sec. 19 and SE$^{1}/_{4}$NE$^{1}/_{4}$ sec. 25, WELLSVILLE. Vanport. *Brachycycloceras* sp. (1).

JEwa-3. Exposures along U.S. Rte. 22 at west end of bridge over Cross Creek, NE$^{1}/_{4}$SE$^{1}/_{4}$SE$^{1}/_{4}$ sec. 6, SMITHFIELD. Ames. *Tainoceras collinsi* (2).

Steubenville Township:

JEst-1. Undescribed locality near Steubenville, STEUBENVILLE EAST or STEUBENVILLE WEST. Ames. *Domatoceras* cf. *D. highlandense* (1).

LAWRENCE COUNTY:

Hamilton Township:

Lh-1. Undescribed locality near Hanging Rock in southeastern part of township (Morningstar's locality 30), IRONTON. Lower Mercer. *Mahoningoceras pottsvillense* (1).

Symmes Township:

Ls-1. Abandoned strip mines of Belville Mining Co., Inc., on south side of Johns Creek, sec. 35, SHERRITTS. Cambridge. OGS 4706. Pseudorthoceras knoxense (57), Metacoceras mcchesneyi (1), *Stenodomatoceras gardi*? (1), *Solenochilus johnstoni*? (1), *Ephippioceras ferratum* (1).

LICKING COUNTY:

Hopewell Township:

LIho-1. Exposure at abandoned cannel coal mine on west side of Hopewell Twp. Rd. 288 (Cooks Hill Rd.) approx. 0.2 mile (0.3 km) north of junction with Licking County Rd. 312 (Flint Ridge Rd.) west of Flint Ridge State Memorial (Morningstar's locality 47), GLENFORD. Lower Mercer. OGS 6294. *Metacoceras perelegans* (1), *Metacoceras* sp. #2 (5), *Latitemnocheilus*? sp. #2 (2), *Ctenobactrites isogramma* (2).

LIho-3. Exposure along Licking County Rd. 312 (Flint Ridge Rd.) just west of junction with Hopewell Twp. Rd. 288 (Clarks Hill Rd.) approx. 1.0 mile (1.6 km) west of Flint Ridge State Memorial (Morningstar's locality 49?), GLENFORD. Lower Mercer. *Ctenobactrites isogramma* (1).

Madison Township:

LIm-1. Float blocks around radio tower on Bald Knob 0.3 mile (0.5 km) north of Licking County Rd. 301 (Blue Jay Rd.) and 0.5 mile (0.8 km) west of Madison Twp. Rd. 313 southeast of Newark (Morningstar's locality 46), HANOVER. Lower Mercer. *Ctenobactrites isogramma* (1).

MAHONING COUNTY:

Canfield Township:

Mc-1. Abandoned strip mine on north side of U.S. Rte. 224 approx. 2.0 miles (3.2 km) west of Canfield, CANFIELD. Putnam Hill. *Pseudorthoceras knoxense* (7), *Poterioceras curtum* (1), *Metacoceras tricarinatum parvinodosum* (1), *Domatoceras oreskovichi* (1), *Liroceras liratum* (3), *Ephippioceras ferratum* (1).

Mc-2. Abandoned strip mine of Leb Coal Co. on east side of Mahoning County Rd. 93 (Crory Rd.) 0.25 to 0.5 mile (0.4 to 0.8 km) south of U.S. Rte. 224, CANFIELD. Putnam Hill. *Brachycycloceras* sp. (1), P*seudorthoceras knoxense* (25), *Mooreoceras normale* (2), *Temnocheilus quinqueliratus*? (1), *Ungeroceras ungeri* (1), *Metacoceras mutabile* (4), *M. perelegans* (2), *Megaglossoceras* sp. (1).

Mc-3. Exposures along tributary on south side of Indian Run between Christs Mission Camp and Optimists Club Boys Camp approx. 0.5 mile (0.8 km) east of Mahoning County Rd. 109 (Raccoon Rd.) and on north side of Mahoning County Rd. 74 (Leffingwell

Rd.), YOUNGSTOWN. Putnam Hill. *Metacoceras tricarinatum tricarinatum* (1), *Domatoceras oreskovichi* (1).

Mc-4. Abandoned limestone quarry on Sawmill Run north of Mahoning County Rd. 110 (Herbert Rd.) and west of abandoned Erie RR approx. 2.0 miles (3.2 km) northwest of Canfield, CANFIELD. Lower Mercer. *Mahoningoceras subquadrangulare* (2).

Ellsworth Township:

Me-1. Abandoned strip mines on east side of Ohio Rte. 45 north of Bowmans Corners and south of Mahoning County Rd. 74 (Leffingwell Rd.) SALEM. Putnam Hill. OGS 6912. *Ctenobactrites isogramma* (1).

Me-3. Abandoned strip mines on east side of Ohio Rte. 45 southeast of road junction at elevation 1151 approx. 1.5 miles (2.4 km) south of Ellsworth, CANFIELD. Putnam Hill. *Pseudorthoceras knoxense* (28), *Ctenobactrites isogramma* (1).

Green Township:

Mg-2. Spoil banks of abandoned shaft mine of New Salem Coal Co. (J. Pascola) on south side of Alt. Ohio Rte. 14 near head of ravine extending Southwest of Millville, SW$^1/_4$ sec. 33, SALEM. Columbiana. OGS 3776. *Brachycycloceras longulum* (1), *Pseudorthoceras knoxense* (10), *Mooreoceras normale* (13), *Poterioceras curtum* (2), *Metacoceras lambi* (1), *M. latum* (1), *M. perelegans* (3), *Latitemnocheilus medioventralis* (1), *Domatoceras obsoletum* (6), *D. shepherdi* (1), *Solenochilus greenensis* (2), *Liroceras liratum* (10).

Mg-3. Exposure along small stream on former Ira Unger farm approx. 100 yards (90 meters) east of Green Twp. Rd. 75 (Knauf Rd.), NW$^1/_4$ sec. 4, SALEM. Putnam Hill. OGS 15068. *Brachycycloceras* sp. (4), *Pseudorthoceras knoxense* (28), *Poterioceras curtum* (2), *Ungeroceras ungeri* (1), *Liroceras liratum* (2).

Mg-4. Spoil banks (no longer accessible) of abandoned Nick Weingart drift mine on northeast side of Middle Fork Little Beaver Creek, E-ctr. sec. 7, SALEM. Putnam Hill. OGS 5608. *Pseudorthoceras knoxense* (26), *Mooreoceras normale* (1), *Poterioceras curtum* (3), *Metacoceras mutabile* (2), *M. tricarinatum tricarinatum* (2), *M. t. parvinodosum* (4), *Parametacoceras* cf. *P. bellatulum* (2), *Domatoceras oreskovichi*? (2).

Mg-6. Abandoned strip mine of New Albany Coal Co. (later Davis Coal Co.) on east side of Ohio Rte. 45 and north of Ohio Rte. 165 (South Range Rd.), SW$^1/_4$ sec. 17 and S-ctr. sec. 18, SALEM. Columbiana. OGS 15070. *Mooreoceras normale* (4), *Poterioceras curtum* (1), *Endolobus ortoni* (1), *Temnocheilus annulonodosus* (7).

Mg-7. Spoil bank of abandoned H. L. Daugherty slope mine on south side of Ohio Rte. 165 (South Range Rd.), NE corner sec. 19, SALEM. Columbiana. OGS 3770. *Mooreoceras normale* (2), *Poterioceras curtum* (1), *Metacoceras perelegans* (3), *Solenochilus greenensis* (2), *Liroceras liratum* (9), *Ephippioceras ferratum* (3).

Mg-10. Spoil bank (no longer accessible) of abandoned Ed Shepherd drift mine (later stripped) on east side of Middle Fork Little Beaver Creek, N-ctr. sec. 33, SALEM. Columbiana. OGS 3775. *Brachycycloceras* sp. (3), *Temnocheilus annulonodosus* (1), *Domatoceras obsoletum* (1), *D. shepherdi* (2), *Liroceras liratum* (7), *Ephippioceras ferratum* (1).

Mg-11. Abandoned J. A. Stouffer drift mine (type locality for Washingtonville shale) east of reservoir on Cherry Valley Run and north of Alt. Ohio Rte. 14 at northeast edge of Washingtonville, SW$^1/_4$ sec. 36, SALEM. Washingtonville, OGS 1710. *Pseudorthoceras knoxense* (7).

Poland Township:

Mp-1. Abandoned quarry and Lake managed by Lowellville Rod and Gun Club north of U.S. Rte. 224 and east of Poland Twp. Rd. 217 (Quarry Rd.) south of Lowellville, CAMPBELL. Lowellville (Poverty Run), Vanport. OGS 5014. Lowellville (Poverty Run): *Pseudorthoceras knoxense* (1); Vanport: *Metacoceras perelegans* (2), *Liroceras liratum* (1), *Ephippioceras ferratum* (2), *Megaglossoceras* sp. (1).

Smith Township:

Ms-2. Strip-mined quarry of Alliance Stone Co. Southwest of junction of Smith Twp. Rd. 13 (Martin Rd.) and Mahoning County Rd. 18 (Middletown Rd.), NE$^1/_4$ sec. 18, ALLIANCE. Putnam Hill-Vanport undifferentiated. OGS 15124. *Pseudorthoceras knoxense* (16).

Ms-3. Abandoned strip mines of Keller Mines, Inc., northeast of Alliance in secs. 7, 8, 17, 18, and 19, ALLIANCE. Putnam Hill. *Michelinoceras*? *unicamera* (8), *Brachycycloceras* sp. (6), *Pseudorthoceras knoxense* (96), *Mooreoceras normale* (11), *Poterioceras curtum* (1), *Metacoceras mutabile* (1), *M. perelegans* (4), *M. tricarinatum tricarinatum* (2), *M. t. parvinodosum* (5), *Endolobus* cf. *E. forbesianus* (1), *Temnocheilus annulonodosus* (4), *Latitemnocheilus* cf. *L. harneri* (3), *Latitemnocheilus* cf. *L. latus* (1), *Ungeroceras ungeri* (2), *Domatoceras oreskovichi* (21), *Solenochilus millhorni* (2), *Solenochilus* cf. *S. springeri* (5), *Liroceras liratum* (5), *Ephippioceras ferratum* (1), *Ctenobactrites isogramma* (1).

Springfield Township:

Msp-1. Abandoned strip mine of R and M Enterprise Mining Co. north of Ohio Rte. 617 (Garfield Rd.) approx. 0.75 mile (l.2 km) east of New Springfield, S-ctr. sec. 28, NEW MIDDLETOWN. Columbiana. *Metacoceras latum* (4), *Temnocheilus annulonodosus* (1), *Ctenobactrites isogramma* (1).

Msp-2. Abandoned strip mine of Thompson Bros. Mining Co. on south side of Ohio Rte. 617 (Garfield Rd.) and east side of Springfield Twp. Rd. 167 (Beard Rd.) just southeast of road junction approx. 0.5 mile (0.8 km) southeast of New Springfield, NW$^1/_4$ sec. 33, NEW MIDDLETOWN. Columbiana. *Metacoceras latum* (6), *Temnocheilus annulonodosus* (1).

Uncertain locality:

Muc-1. Undescribed location. Columbiana. *Mooreoceras normale* (1).

MEIGS COUNTY:

Columbia Township:

MEco-1. Exposure along Ohio Rte. 32 (formerly Ohio Rte. 346) (Appalachian Hwy.) west of Mt. Blanco, NW$^1/_4$SW$^1/_4$SW$^1/_4$ sec. 24, VALES MILLS. Brush Creek. *Pseudorthoceras knoxense* (3), *Mooreoceras normale* (7), *Metacoceras* sp. #1 (2).

MUSKINGUM COUNTY:

Cass Township:

MUc-2. Exposure along the Highlands and Cass Twp. Rd. 77 (Redbud Rd.) between Dresden and Frazeysburg, DRESDEN. Putnam Hill-Vanport undifferentiated. OGS 770. *Brachycycloceras* sp. (1).

Harrison Township:

MUha-1. Undescribed exposures along Cedar Run, secs. 31 and 32, PHILO. Portersville. *Metacoceras mcchesneyi* (1).

Hopewell Township:

MUho-3. Abandoned G. L. Porter (also Porter Bros.) mine (site graded over and obliterated by I-70) at junction of Muskingum County Rd. 28 (Hopewell Rd.) and I-70, N-ctr. sec. 3, T 18 N, R 15 W, GRATIOT. Putnam Hill-Vanport undifferentiated. OGS 433. *Brachycycloceras* sp. (1), *Pseudorthoceras knoxense* (2), *Temnocheilus annulonodosus* (3), *Latitemnocheilus* sp. (1).

MUho-5. Exposure in stream channel (type locality for Poverty Run limestone), SE$^1/_4$SW$^1/_4$ sec. 13, T 18 N, R 15 W (Morningstar's locality 19), GRATIOT. Lowellville (Poverty Run). OGS 421. *Pseudorthoceras knoxense* (30).

MUho-9. Exposure along northeast-extending ravine on Fisher farm, SW$^1/_4$ sec. 6, T 18 N, R 15 W, GRATIOT. Putnam Hill. *Brachycycloceras* sp. (4), *Metacoceras clinocostatum* (3), *Ctenobactrites isogramma* (1).

Muskingum Township:

MUmu-1. Abandoned strip mines extending north-south for approx. 4.0 miles (6.4 km) south of north boundary of Muskingum Twp. along Muskingum County Rd. 2 and Muskingum Twp. Rd. 416 (Dresden Rd.) between Dresden and Stringtown, DRESDEN. Washingtonville. *Brachycycloceras* sp. (1), *Pseudorthoceras knoxense* (2), *Mooreoceras tuba* (2), *Metacoceras latum* (12), *Solenochilus* sp. (1), *Liroceras liratum* (4).

MUmu-3. Undescribed locality along Blunt Run (Morningstar's locality 27), DRESDEN. Lower Mercer. *Endolobus ortoni*? (1).

Springfield Township:

MUsp-1. Exposure at the Dugway along Muskingum Ave. at Putnam Hill (type locality for Putnam Hill limestone) on west side of Muskingum River in Zanesville, NE$^1/_4$ sec. 1, ZANESVILLE WEST. Putnam Hill and Vanport. OGS 788. Putnam Hill: *Pseudorthoceras knoxense* (4), *Liroceras liratum* (1); Vanport: *Latitemnocheilus bellicosus* (2).

Union Township:

MUu-2. Exposure along tributary to Crooked Creek west of former Richard Rice (later Tony Fazekas) farm buildings on Muskingum County Rd. 65 approx. 1.5 miles (2.4 km) south of New Concord, NEW CONCORD. Ames. *Mooreoceras normale* (1), *Tainoceras marylandicum*? (2), *Tainoceras* sp. #2 (2), *Metacoceras* cf. *M. mcchesneyi* (1), *Domatoceras* cf. *D. highlandense* (1), *Domatoceras* sp. (1).

Uncertain locality:

MUuc-1. Undescribed location. Lower Mercer. *Pseudorthoceras knoxense* (2).

NOBLE COUNTY:

Olive Township:

No-1. Undescribed location, CALDWELL SOUTH. Ames. *Pseudorthoceras knoxense* (2).

No-5. Exposure along Olive Twp. Rd. 86 northwest of junction with Noble County Rd. 7, W-ctr. sec. 15, CALDWELL SOUTH. Gaysport. OGS 15968. *Pseudorthoceras knoxense* (5), *Mooreoceras normale* (1).

PERRY COUNTY:

Bearfield Township:

Pb-1. Exposure at north end of abandoned Wabash RR tunnel cut (railroad never built) (type locality for Portersville shale and limestone), N$^1/_2$SW$^1/_4$ sec. 24, DEAVERTOWN. Portersville. OGS 10375. *Brachycycloceras* sp. (2), *Pseudorthoceras knoxense* (7), *Metacoceras mcchesneyi* (1).

Clayton Township:

Pcl-1. Abandoned strip mine in vicinity of junction of Clayton Twp. Rd. 45 and Perry County Rd. 47, NW$^1/_4$SE$^1/_4$ sec. 5, FULTONHAM. Columbiana or Vanport. *Ungeroceras ungeri*? (1).

Jackson Township:

Pj-2. Undescribed locality in vicinity of Junction City, JUNCTION CITY. Lower Mercer. *Pseudorthoceras knoxense* (1).

Monday Creek Township:

Pmc-4. Strip mine of Logan Clay Products Co., E-ctr. sec. 19, GORE. Putnam Hill. *Pseudorthoceras knoxense* (4).

SCIOTO COUNTY:

Porter Township:

SCp-2. Exposure near mouth of Sugar (Sugar Camp) Creek on former Joseph Jenkins farm, SW$^1/_4$ sec. 13 (Morningstar's locality 2), WHEELERSBURG. Sharon. *Liroceras liratum* (1).

STARK COUNTY:

Bethlehem Township:

Sb-1. Undescribed location, sec. 29, NAVARRE. Lower Mercer. *Endolobus* cf. *E. forbesianus* (1).

Sb-2. Exposure in N & W RR cut under Blough Ave. bridge, NW$^1/_4$SW$^1/_4$ sec. 16, NAVARRE. Lower Mercer? *Pseudorthoceras knoxense* (1).

Canton Township:

Sc-2. Undescribed location in Canton, CANTON EAST or CANTON WEST. Lower Mercer. *Solenochilus peculiare* (1).

Sc-5. Abandoned limestone quarry 0.25 to 0.5 mile (0.4 to 0.8 km) south of Waco business district, SW$^1/_4$ sec. 14, CANTON EAST. Putnam Hill. *Ungeroceras ungeri* (1).

Pike Township:

Spk-1. Abandoned strip mine on north side of Gracemont St., NW$^1/_4$ sec. 30, BOLIVAR. Putnam Hill. *Thoracoceras*? sp. (1).

Sandy Township:

Ss-3. Abandoned strip mines of Magnolia Mining Co. east of Indian Run Dr. and west of Ohio Rte. 44, secs. 3 and 4, WAYNESBURG. Washingtonville. *Metacoceras latum* (2).

Ss-4. Abandoned strip mine of D and M Coal Co., SE$^1/_4$ sec. 10, MALVERN. Columbiana. *Liroceras liratum* (4).

Ss-5. Abandoned strip mine of Magnolia Mining Co., NW$^1/_4$ sec. 21, WAYNESBURG. Columbiana and Washingtonville. OGS 14648. Columbiana: *Mooreoceras normale* (4), *Metacoceras perelegans* (2), *Liroceras liratum* (1); Washingtonville: *Solenochilus greenensis* (1).

Ss-6. Abandoned strip mine of D and M Coal Co., NE$^1/_4$ sec. 15, MALVERN. Columbiana. *Michelinoceras*? *unicamera* (1), *Mooreoceras normale* (2).

SUMMIT COUNTY:

Springfield Township:

SUsp-2. Undescribed location near Springfield (North Springfield?, now Ellet?), AKRON EAST. Lower Mercer. *Endolobus ortoni* (1).

TUSCARAWAS COUNTY:

Dover Township:

Td-4. Abandoned strip mine on Southwest side of Ohio Rte. 39, NE$^1/_4$NW$^1/_4$ sec. 2, DOVER. Putnam Hill-Vanport undifferentiated. *Pseudorthoceras knoxense* (15), *Poterioceras curtum* (1), *Metacoceras tricarinatum parvinodosum* (1), *Temnocheilus annulonodosus* (7), *Ungeroceras ungeri* (1), *Domatoceras oreskovichi* (1), *Solenochilus millhorni* (2), *Solenochilus* cf. *S. springeri* (1).

Franklin Township:

Tfr-1. Exposure on south side of Sugar Creek just below

Beach City dam, W-ctr. sec. 1?, NAVARRE. Lowellville (Poverty Run). *Brachycycloceras* sp. (1), *Pseudorthoceras knoxense* (28), *Latitemnocheilus* cf. *L. johnsoni* (1), *Solenochilus peculiare*? (1).

Goshen Township:

Tg-1. High, steep exposure along south side of U.S. Rte. 250 just southeast of junction with I-77 south of New Philadelphia, NEW PHILADELPHIA. Putnam Hill. *Pseudorthoceras knoxense* (59), *Mooreoceras normale* (1).

Tg-2. Location described on specimen label as "Roof shales of Lower Kittanning coal, Allegheny Formation, Goshen" on Southwest side of Tuscarawas River approx. 2.5 miles (4.0 km) southeast of New Philadelphia, NEW PHILADELPHIA. Columbiana. *Solenochilus greenensis* (1).

Lawrence Township:

Tl-1. Abandoned shale pit of Bolivar Clay Products Co. on west side of N & W RR at west edge of Bolivar, BOLIVAR. Vanport. OGS 1914, 4996. *Poterioceras curtum* (1), *P. subellipticum* (1), *Temnocheilus quinqueliratus* (1), *Solenochilus bognari* (1), *Liroceras liratum* (1), *Condraoceras*? sp. (1).

Tl-7. Exposure on north side of Tuscrawas County Rd. 103 (Norris Orchard Rd.) east of road junction at elevation 913 (this part of road now abandoned) on east side of Tuscarawas River approx. 0.4 mile (0.6 km) east-southeast of Bolivar, BOLIVAR. Lower Mercer. *Pseudorthoceras knoxense* (1).

Sandy Township:

Ts-1. Abandoned borrow pit on northwest side of Ohio Rte. 800 (formerly Ohio Rte. 8) and Conrail RR approx. 1.0 mile (1.6 km) Southwest of Mineral City and 0.7 mile (1.1 km) northeast of Valley Junction, DOVER. Vanport. *Pseudorthoceras knoxense* (10), *Metacoceras mutabile* (1).

Ts-4. Abandoned strip mine of Zoar Mining Co. on north side of Sandy Twp. Rd. 405, SW$^{1}/_{4}$NW$^{1}/_{4}$ sec. 6, BOLIVAR. Columbiana. OGS 16224. *Brachycycloceras* sp. (1), *Pseudorthoceras knoxense* (5).

Sugar Creek Township:

Tsc-1. Abandoned strip mine of Belden Brick Co. north of Ohio Rte. 39 and east of Ohio Rte. 93 northeast of Shanesville and north of Sugarcreek, NW$^{1}/_{4}$ sec. 2 and NE$^{1}/_{4}$ sec. 3, SUGARCREEK. Putnam Hill-Vanport undifferentiated. OGS 13316. *Michelinoceras*? *unicamera* (1), *Pseudorthoceras knoxense* (14).

Tsc-3. Abandoned strip mine of Belden Brick Co., SW$^{1}/_{4}$ sec. 3, SUGARCREEK. Putnam Hill. *Mooreoceras normale* (1), *Temnocheilus annulonodosus* (2).

Warren Township:

Tw-1. Strip mine of Puskarich Bros. Mining Co. east of Tuscarawas County Rd. 90 and east and north of Conotton Creek, S$^{1}/_{2}$ sec. 28, MINERAL CITY. Columbiana. *Solenochilus greenensis* (1).

Warwick Township:

Twa-1. Abandoned strip mines on Southwest side of Fox Valley in southwestern part of quarter-township 4 and extending northwest into Clay Twp., NEW PHILADELPHIA. Columbiana-Dorr Run- Washingtonville undifferentiated. *Endolobus* cf. *E. forbesianus* (2), *Solenochilus greenensis* (1).

Wayne Township:

Twy-2. Abandoned strip mines east of elevation 1300 at road junction Southwest of common boundary of Holmes, Stark, and Tuscarawas Counties, WILMOT. Upper Mercer. *Brachycycloceras* sp. (1), *Pseudorthoceras knoxense* (1), *Mooreoceras normale* (1).

Twy-5. Wallick strip mine of Belden Brick Co. on east side of Ohio Rte. 93, SE$^{1}/_{4}$ sec. 16 and NE$^{1}/_{4}$ sec. 25, STRASBURG. Putnam Hill. *Endolobus* cf. *E. forbesianus* (1).

York Township:

Ty-1. Abandoned strip mine of Howe Coal Co. south of Tuscarawas County Rd. 55, NW$^{1}/_{4}$ sec. 24, NEW PHILADELPHIA. Washingtonville. *Temnocheilus annulonodosus* (1), *Latitemnocheilus*? sp. #1 (1).

Ty-2. Abandoned strip mine approx. 0.75 mile (1.2 km) northwest of junction of Tuscarawas County Rds. 21 and 51 at Blackband, STONE CREEK. Washingtonville. *Poterioceras curtum* (1).

Ty-3. Exposure in abandoned strip mine (formerly a borrow pit) of Zoar Mining Co. on east side of I-77 and east of Stone Creek, NW$^{1}/_{4}$ sec. 17, NEW PHILADELPHIA. Putnam Hill. *Brachycycloceras* sp. (1), *Pseudorthoceras knoxense* (131), *Metacoceras clinocostatum* (1), *Metacoceras* sp. #1 (1), *Endolobus* cf. *E. forbesianus* (1), *Temnocheilus annulonodosus* (1), *Latitemnocheilus* cf. *L. harneri* (1), *Latitemnocheilus* cf. *L. latus* (1), *Domatoceras oreskovichi* (1), *Liroceras liratum* (1), *Ctenobactrites isogramma* (2).

Ty-5. Abandoned strip mine of Howe Coal Co. on east side of Stone Creek, sec. 25?, STONE CREEK. Washingtonville. *Mooreoceras normale* (1), *Metacoceras latum* (15), *M. perelegans* (1).

VINTON COUNTY:

Elk Township:

Vel-11. Abandoned strip mine on south side of abandoned Elk Twp. Rd. 21, N$^{1}/_{2}$NE$^{1}/_{4}$ sec. 17 (Morningstar's locality 84 and type locality for McArthur shale and limestone), ZALESKI. Putnam Hill. OGS 1438. *Pseudorthoceras knoxense* (21).

Vel-12. Abandoned strip mine of Vinton Coal Co. on northeast side of Elk Twp. Rd. 17 approx. 1.1 miles (1.8 km) north-northwest of intersection with U.S. Rte. 50 (at elevation 799), NW$^{1}/_{4}$ sec. 17, ALLENSVILLE. Putnam Hill. OGS 238. *Pseudorthoceras knoxense* (42).

Vel-13. Uncertain location, possibly at small abandoned underground mine on south side of a small tributary to Elk Fork and south of Vinton County Rd. 7 on former property of Wm. Jacobs, NE$^{1}/_{4}$ sec. 25, MCARTHUR. Zaleski. *Liroceras liratum* (1).

Vel-15. Abandoned strip mine on J. A. Crow property on south side of U.S. Rte. 50, NW$^{1}/_{4}$ sec. 27, MCARTHUR. Putnam Hill. OGS 11819. *Pseudorthoceras knoxense* (84), *Mooreoceras normale* (1), *Poterioceras curtum* (1), *Metacoceras tricarinatum tricarinatum* (3), *Endolobus* cf. *E. forbesianus* (2), *Latitemnocheilus* cf. *L. harneri* (2), *Latitemnocheilus* cf. *L. johnsoni* (1), *Ungeroceras ungeri* (7), *Domatoceras oreskovichi* (3), *Solenochilus millhorni* (1), *Solenochilus* cf. *S. springeri* (1), *Liroceras liratum* (1), genus indeterminate #1 sp. (1), Genus indeterminate #2 sp. (1), *Ctenobactrites isogramma* (1).

Vel-19. Abandoned strip mine of Vinton Coal Co. on northeast side of Elk Twp. Rd. 17, SE$^{1}/_{4}$SE$^{1}/_{4}$ sec. 7, ALLENSVILLE, Putnam Hill-Vanport undifferentiated. *Michelinoceras*? *unicamera* (1), *Pseudorthoceras knoxense* (22), *Metacoceras* sp. #3 (1), *Latitemnocheilus* cf. *L. johnsoni* (1), *Solenochilus* cf. *S. springeri* (1).

Vel-20. Abandoned strip mines between Elk Twp. Rds. 11 and 14, E-ctr. and NE$^{1}/_{4}$ sec. 15, ZALESKI. Vanport. *Brachycycloceras* sp. (2), *Metacoceras clinocostatum* (1), *Ctenobactrites isogramma* (1).

Vel-24. Abandoned strip mine (now reclaimed) south of junction of Vinton County Rds. 25 and 27 at elevation 937, SW$^{1}/_{4}$SW$^{1}/_{4}$ sec. 29, HAMDEN. Vanport.

Metacoceras perelegans (1), *M. tricarinatum tricarinatum* (1).

Vel-26. Exposures along North Fork Rock Hollow on Goodwin farm, SE$^1/_4$NE$^1/_4$ sec. 32, MCARTHUR. Lower Mercer. OGS 13276. *Pseudorthoceras knoxense* (3), *Metacoceras* sp. #2 (1), *Latitemnocheilus*? sp. #2 (1).

Swan Township:

Vs-3. Abandoned strip mine of Central States Coal Co. on Merz farm, ctr. sec. 10, ZALESKI. Vanport. *Pseudorthoceras knoxense* (3), *Metacoceras perelegans* (1), *Ephippioceras ferratum* (1).

OUT-OF-STATE LOCALITIES

ILLINOIS

ROCK ISLAND COUNTY:

Hampton Township:

IL:RIh-1. Exposure at Carbon Cliff, sec. 4, T 17 N, R 1 E, COAL VALLEY. Seville. *Latitemnocheilus latus* (1).

KANSAS

MIAMI COUNTY:

Miami Township:

K:Mm-1. Exposure near center of south border of sec. 10, T 18 S, R 24 E, NEW LANCASTER. Winterset. *Metacoceras simile* (1).

MARYLAND

ALLEGANY COUNTY:

(no township)

MD:Ams-1. Exposure at Mine #19 just east of Mt. Savage, CUMBERLAND. Ames. *Tainoceras marylandicum* (2).

GARRETT COUNTY:

(no township)

MD:Gtc-1. Abandoned strip mines along Laurel Run near Tasker Corners, GORMAN. Ames. *Tainoceras marylandicum* (5).

MISSOURI

HENRY COUNTY:

Bogard Township:

MO:Hbo-1. Abandoned Ewing strip mine, sec. 36, T 43 N, R 28 W, HARTWELL. Cherokee. *Parametacoceras bellatulum* (12).

MO:Hbo-2. Abandoned Gooch strip mine, sec. 15, T 43 N, R 28 W, HARTWELL or QUICK CITY. Cherokee. *Parametacoceras bellatulum* (1).

MO:Hbo-3. Abandoned Lear strip mine, sec. 15, T 43 N, R 28 W, HARTWELL or QUICK CITY. Cherokee. *Parametacoceras bellatulum* (7).

MO:Hbo-4. Abandoned Overby strip mine, sec. 21, T 43 N, R 28 W, CREIGHTON or QUICK CITY. Cherokee. *Parametacoceras bellatulum* (1).

Davis Township:

MO:Hd-1. Abandoned Vansant strip mine, sec. 22, T 41 N, R 27 W, CLINTON SOUTH. Cherokee. *Domatoceras williamsi* (4?).

Fields Creek Township:

MO:Hfc-1. Abandoned Tillman strip mine, NE$^1/_4$NE$^1/_4$ sec. 23, T 42 N, R 26 W, CLINTON NORTH. Cherokee. *Latitemnocheilus harneri* (1).

Windsor Township:

MO:Hw-1. Abandoned Bowens mine near Windsor, T 43 N or T 44 N, R 23 W or R 24 W, WINDSOR? Cherokee. *Domatoceras williamsi* (1).

JACKSON COUNTY:

Blue Township:

MO:Jb-1. Exposure in the Missouri River bluff approx. 0.5 mile (0.8 km) northeast of Sugar Creek Station, sec. 22, T 50 N, R 32 W, LIBERTY. Winterset. *Condraoceras primum* (2), *Metacoceras simile* (5).

JASPER COUNTY:

Joplin Township:

MO:JAj-1. Abandoned mine 1.5 miles (2.4 km) south of Carterville, SE$^1/_4$ sec. 20, T 28 N, R 32 W, WEBB CITY. Burgner. *Mahoningoceras pottsvillense* (1).

LAFAYETTE COUNTY:

Davis Township:

MO:Ld-1. Undescribed location, SE$^1/_4$NW$^1/_4$, sec. 15, T 49 N, R 25 W, HIGGINSVILLE. Cherokee. *Parametacoceras bellatulum* (1).

VERNON COUNTY:

Osage Township:

MO:Vo-1. Abandoned strip mine approx. 1.5 miles (2.4 km) east of Arthur, NW$^1/_4$NW$^1/_4$ sec. 4, T 37 N, R 31 W, RICH HILL. Cherokee. *Latitemnocheilus harneri* (1).

NEBRASKA

CASS COUNTY:

Louisville Township:

N:Cl-1. Quarry of National Stone Co. approx. 2.0 miles (3.2 km) northeast of Louisville, sec. 12, T 12 N, R 11 E, SPRINGFIELD. Wyandotte. *Poterioceras subellipticum* (1).

PENNSYLVANIA

ALLEGHENY COUNTY:

East Deer Township:

PA:Aed-1. Exposures near Glassmere, NEW KENSINGTON WEST. Brush Creek. *Coelogasteroceras dubium* (4).

Patton Township:

PA:Apa-1. Exposure near Pitcairn, BRADDOCK. Ames. *Tainoceras collinsi* (1).

Plum Township:

PA:Apl-1. Exposures in the vicinity of Logans Ferry, NEW KENSINGTON WEST. Woods Run (Portersville). *Domatoceras* cf. *D. highlandense* (1).

Sewickley Heights Township:

PA:Ash-1. Exposure near Sewickley, AMBRIDGE. Brush Creek. *Coelogasteroceras dubium* (1).

BEAVER COUNTY:

Brighton Township:

PA:Bb-1. Abandoned Tygart quarry (type locality for Vanport limestone) near Vanport on northwest side of Ohio River approx. 3.0 miles (4.8 km) Southwest of mouth of Beaver River, BEAVER. Vanport. *Ungeroceras ungeri*? (1).

WESTMORELAND COUNTY:

Allegheny Township:

PA:Wa-1. Exposures at Gosser Hill across the Kiskiminetas River from Leechburg, VANDERGRIFT. Woods Run (Portersville). *Domatoceras* cf. *D. highlandense* (1).

WEST VIRGINIA

MONONGALIA COUNTY:

Morgan Township:

WV:Mm-1. Exposure in back of former Top Hat Inn, 1551 Sabradon Drive, Morgantown, MORGANTOWN. Ames. *Tainoceras collinsi* (1).

PRESTON COUNTY:

Reno Township:

WV:Pr-1. Abandoned quarry on east side of West Virginia Rte. 92 approx. 0.7 mile (1.1 km) northeast of Barbour-Preston County line at Dent, FELLOWSVILLE. Ames. *Mooreoceras tuba*? (1).

FOREIGN LOCALITIES

ENGLAND

Eim-1. Balladoole, Isle of Man, England, U.K. Middle Viséan (B_2) limestone. *Temnocheilus coronatus* (2).

IRELAND

Icli-1. Little Island, Cork, Ireland. Lower Carboniferous limestone. *Temnocheilus coronatus* (1).

PLATE 1-1.—*Ctenobactrites*, *Michelinoceras*?, and *Thoracoceras*?

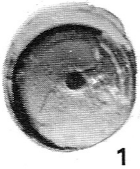
FIGURES 1-7. *Michelinoceras*? *unicamera* (Smith). Putnam Hill unit.

1. End view of hypotype showing septum and position of siphuncle, X4; loc. Ms-3; OSU 29318.
2. Longitudinal sectional view of partial phragmocone of incomplete hypotype, X3; loc. Vel-19; OSU 29275.
3. Longitudinal sectional view of partial phragmocone of incomplete hypotype, X5; loc. Ms-3; OSU 29273.
4. Lateral view of exfoliated incomplete phragmocone of hypotype, X2; loc. Ms-3; OSU 29319.
5. Long view of incomplete hypotype, X1; loc. HOc-3; OSU 29274.
6. Lateral view of partially exfoliated incomplete phragmocone of hypotype, X2; loc. Ms-3; OSU 29317.
7. Long view of one partially exfoliated cameral segment of hypotype, X4; loc. Ms-3; OSU 29319.

8-11, 14. *Ctenobactrites isogramma* (Meek).

8. Lateral view of fairly complete hypotype, X1; Lower Mercer unit, loc. LIho-3; OSU 4710.
9. Long view of incomplete hypotype, X2; Putnam Hill unit, loc. Me-3; OSU 28801.
10. Long view of incomplete hypotype, X1; Upper Mercer unit, loc CSje-1; OSU 15239.
11. Long view of partially exfoliated incomplete hypotype, X2; Putnam Hill unit, loc. Ty-3; OSU 28802.
14. Long view of an exfoliated incomplete hypotype showing parts of body chamber and phragmocone, X1; Lower Mercer unit, loc. LIho-1; OSU 15240.

12, 13. *Thoracoceras*? sp. Long polished (**12**) and external lateral (**13**) views of incomplete specimen, X6; Putnam Hill unit, loc. Spk-1; OSU 29249.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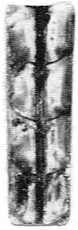
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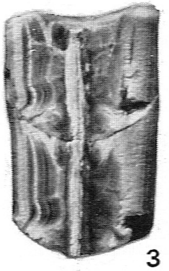
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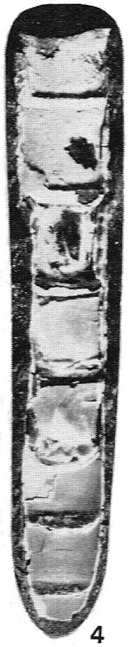
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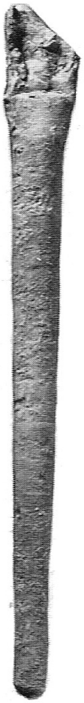
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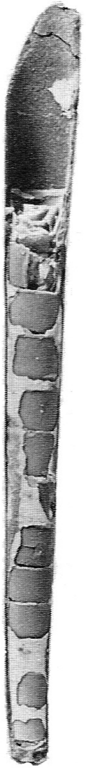
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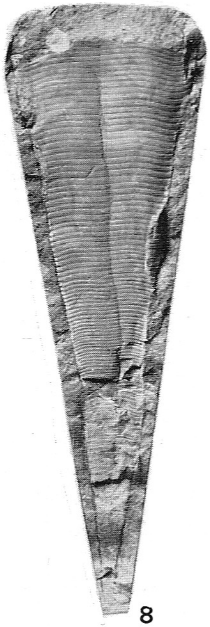
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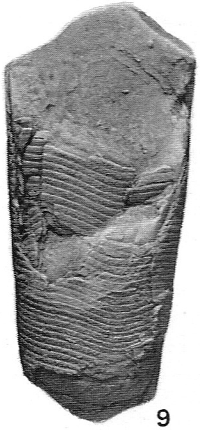
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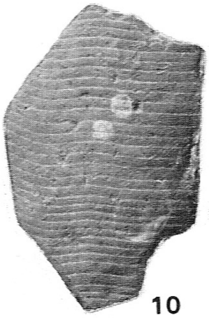
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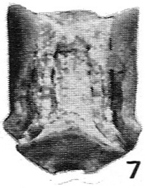
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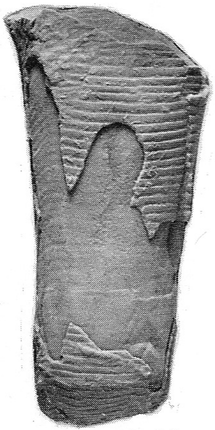
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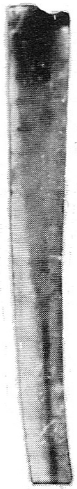
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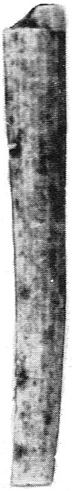
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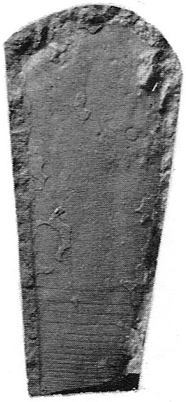
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PLATE 1–1

PLATE 1-2.—*Brachycycloceras*

FIGURES 1, 4, 5. *Brachycycloceras longulum* Miller & Owen. External mold of incomplete hypotype (formerly holotype of *B. ohioense* Sturgeon), X5 (approx.); Columbiana unit, loc. Mg-2; OSU 18707.

1. Long view showing annulations and rapid expansion of part adjacent to apex.

4, 5. Long views showing annulations, rapid expansion of apicad portion, and, indistinctly, some details of septa and siphuncle (**5**).

2, 3, 6, 8-10. *Brachycycloceras* spp.

2. Long external mold of exfoliated incomplete specimen showing annular ridges, troughs, and fine lines, X3 (approx.); Washingtonville unit, loc. MUmu-1; OSU 28814.

3. Enlarged portion of specimen in **2** showing details of annulations and intervening areas with fine lines and striations, X10.

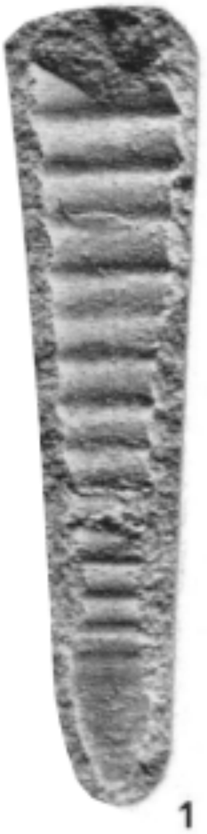
6. External mold of incomplete specimen showing annulations, interspaces, and faint transverse fine lines, X3; Vanport unit, loc. Vel-20; OSU 28812.

8. Long view of exfoliated fragmental specimen showing some details of annular ridges and troughs, X1½; Ames unit, Aal-41; OSU 28815.

9. Enlarged long portion of external mold of incomplete specimen showing annulations and intervening areas with fine lines and striations, X10; Putnam Hill unit, loc. Mc-2; OSU 28807.

10. Long view of short fragment of partially exfoliated specimen showing annulations, interannular areas, and fine transverse lines, X5; Putnam Hill unit, loc. MUc-2; OSU 28809.

7. *Brachycycloceras*? cf. *B.*? *spectrum* Hansman. Long view of exfoliated incomplete doubtful hypotype showing variations in annulations and sinuous trace of tube or boring, X3; Vanport unit, loc. Csc-1; OSU 28810.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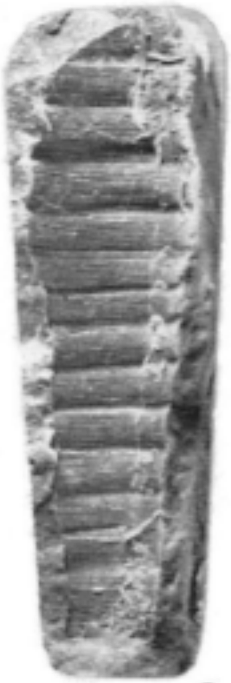
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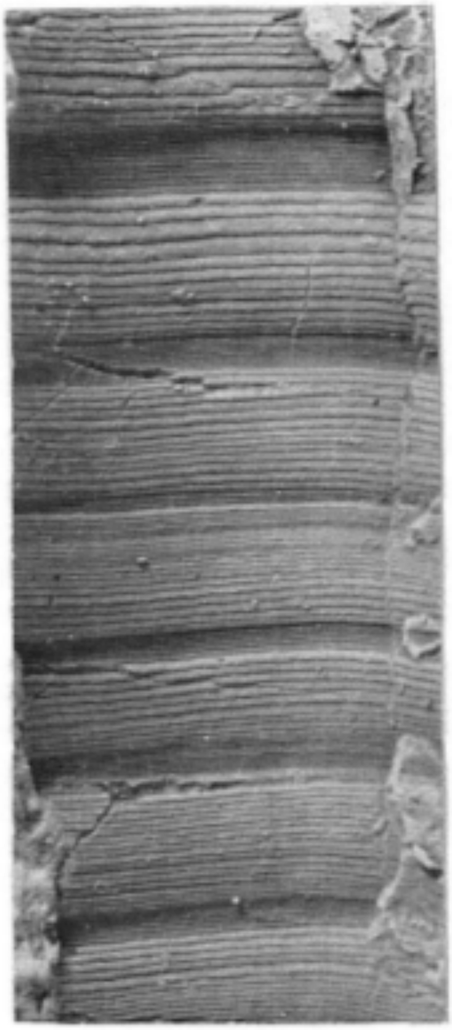
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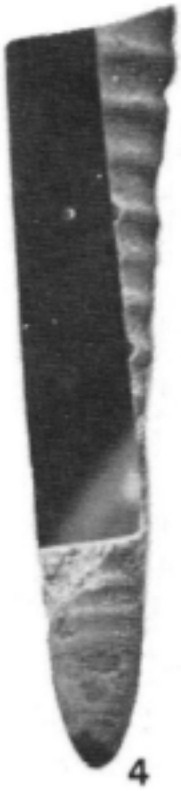
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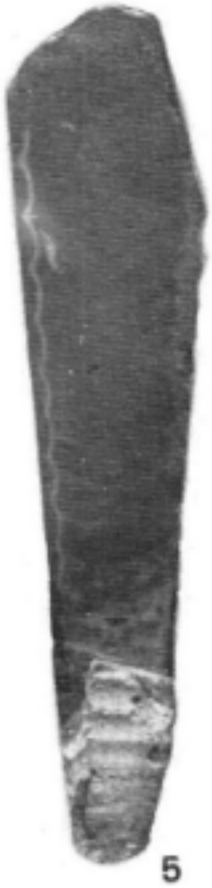
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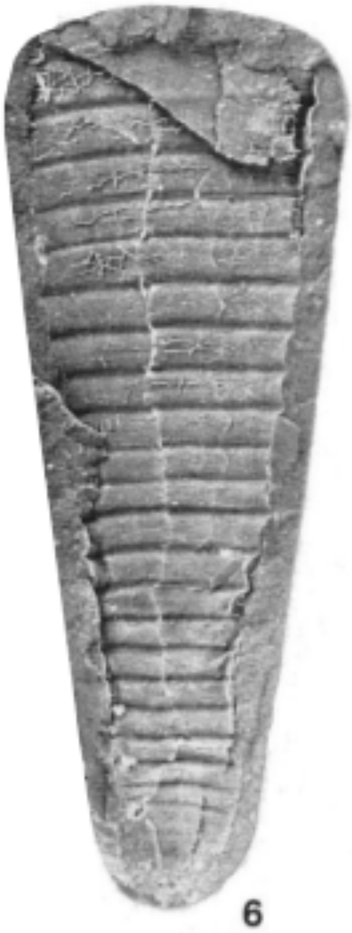
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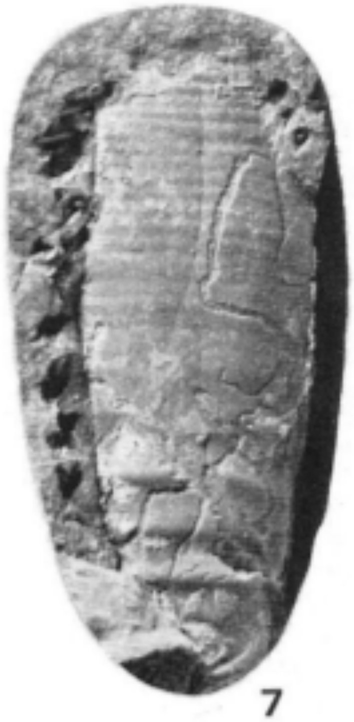
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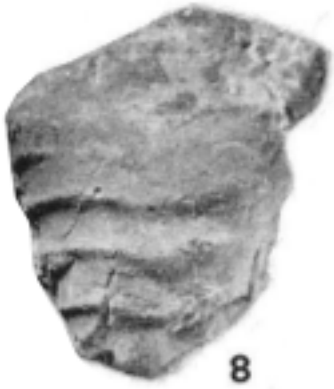
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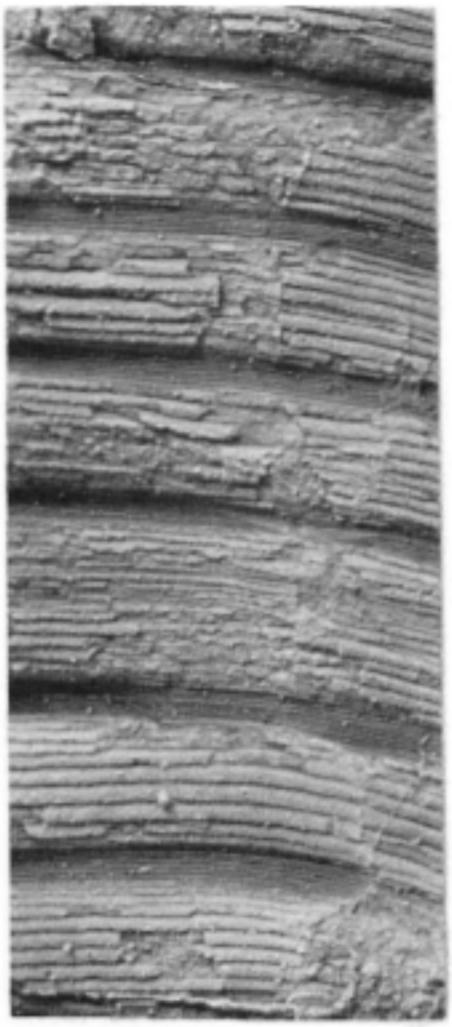
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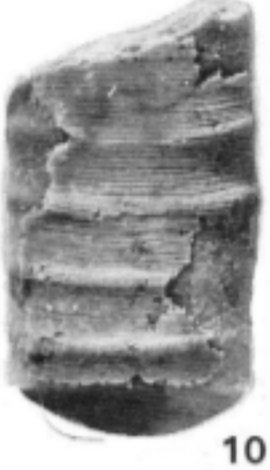
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PLATE 1–2

PLATE 1-3.—*Pseudorthoceras knoxense* (McChesney)

FIGURE 1. Long view of fairly large but incomplete distorted and exfoliated hypotype showing traces of sutures, X2; Putnam Hill-Vanport units undifferentiated, loc. MUho-3; OSU 29425.

2, 3. Lateral (**2**) and dorsal (**3**) views of apicad end of incomplete hypotype, X2; Putnam Hill unit, loc. Mg-4; OSU 29278.

4. Polished long dorsoventral view of apicad end of incomplete robust hypotype showing indistinct details of septa, siphuncle, and secondary deposits, X2?; Putnam Hill unit, loc. unknown; OSU 30610.

5, 6. Dorsal (**5**) and lateral (**6**) views of robust incomplete hypotype showing exterior of test, X2; Putnam Hill unit, loc. Tg-1; OSU 29368.

7, 8. Cross-sectional views of conchs of two hypotypes showing septa and position of siphuncle, X3; Brush Creek unit, loc. Cma-3; OSU 29395.

9. Polished long dorsoventral view of apicad tip of incomplete robust hypotype showing details of septa, siphuncle, and secondary deposits, X2; Gaysport unit, loc. No-5; OSU 30607.

10. Long view of incomplete hypotype showing smooth exterior of test, X2; Brush Creek unit, loc. Ale-35; OSU 29291.

11. Polished long view of incomplete hypotype showing septa and secondary deposits, X1½; Portersville unit, loc. Pb-1; OSU 29393.

12. Polished long view of apicad end of incomplete hypotype showing details of septa, siphuncle, and secondary deposits, X3; Brush Creek unit, loc. Aa-41; OSU 29366.

13. Polished long view of apicad end of incomplete hypotype showing indistinct details of septa, siphuncle, and secondary deposits, X3; Putnam Hill-Vanport units undifferentiated, loc. Td-4; OSU 29385.

14. Polished long view of apicad end of incomplete hypotype showing indistinct details of septa, siphuncle, and secondary deposits, X3; Putnam Hill unit, loc. Ms-3; OSU 29398.

15. Polished long view of fragment of phragmocone of incomplete hypotype showing details of septa, siphuncle, and cameral deposits, X2; Brush Creek unit, loc. Aa-41; OSU 29268.

16. Lateral view of apicad end of incomplete hypotype showing exterior of test, X2; Putnam Hill unit, loc. Ms-3; OSU 29397.

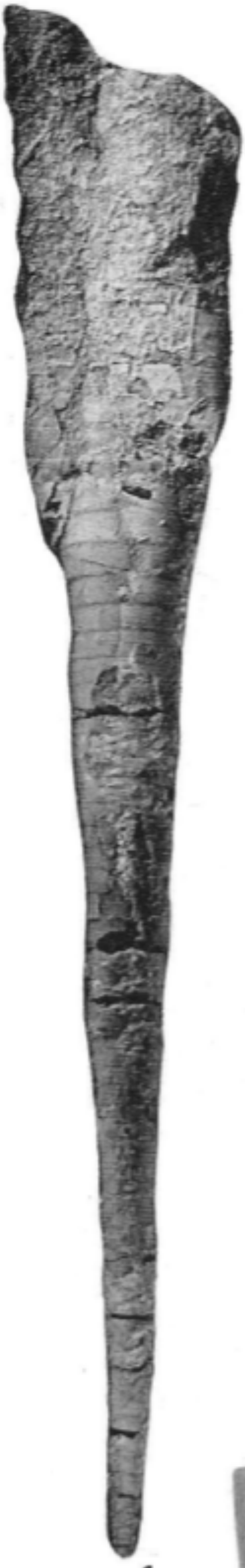
17. Lateral view of apicad end of incomplete hypotype showing exterior of test, X3; Putnam Hill unit, loc. HOc-3; OSU 29386.

18. Polished long view of portion of phragmocone of incomplete hypotype showing details of septa, siphuncle, and cameral deposits, X1½; Putnam Hill unit, loc. Vel-12; OSU 29356.

19. Polished long view of portion of phragmocone of incomplete hypotype showing details of septa, siphuncle, and cameral deposits, X2; Brush Creek unit, loc. Aa-41; OSU 29355.

20. Long view of portion of phragmocone of exfoliated incomplete hypotype showing partial suture pattern, X1½; Putnam Hill unit, loc. Mc-2; OSU 29381.

21. Long view of incomplete and slightly distorted robust hypotype showing some surface features of test, X1; Putnam Hill unit, loc. Ms-3; OSU 29298.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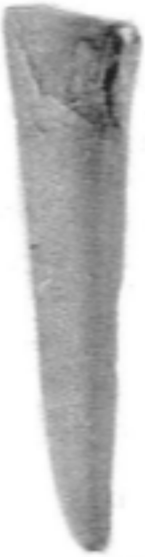
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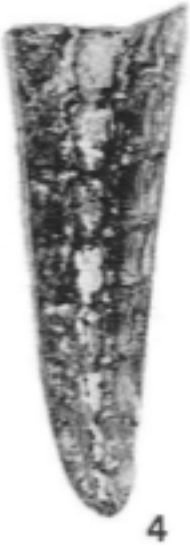
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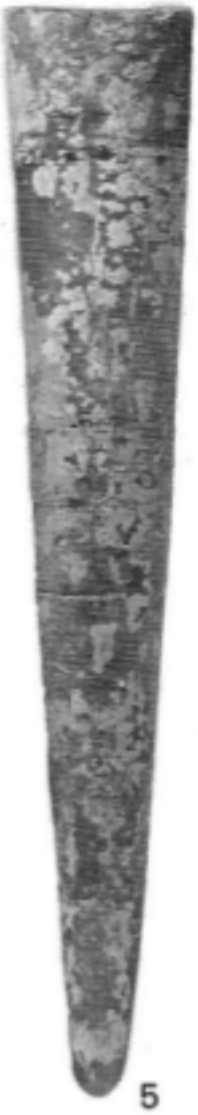
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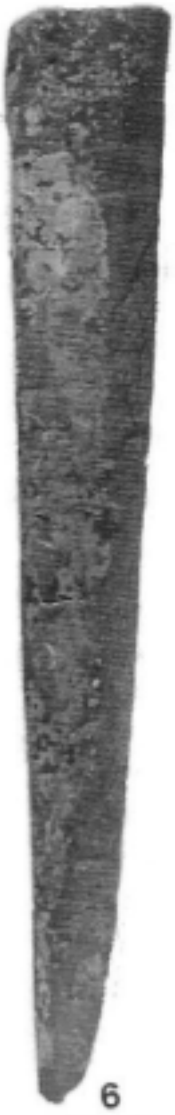
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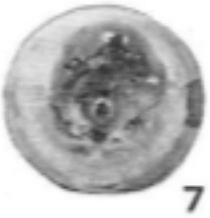
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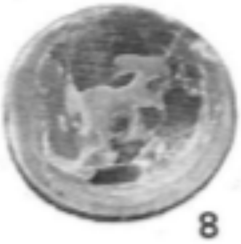
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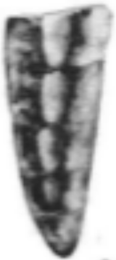
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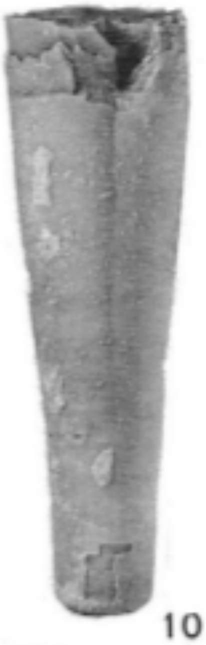
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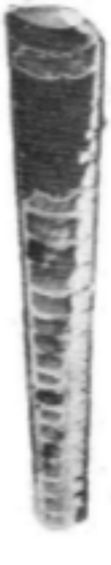
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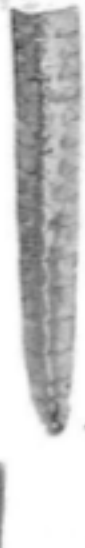
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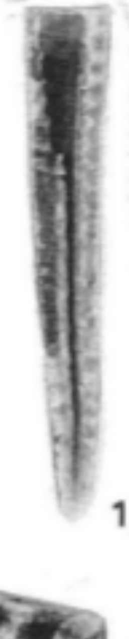
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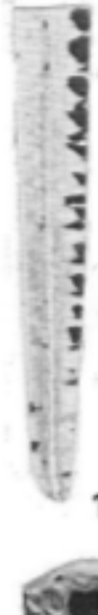
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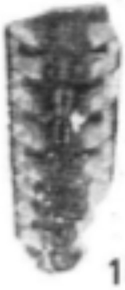
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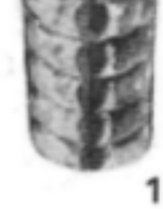
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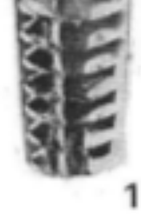
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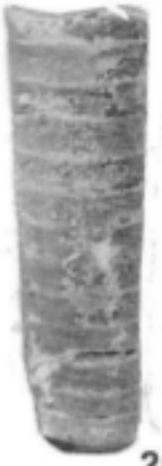
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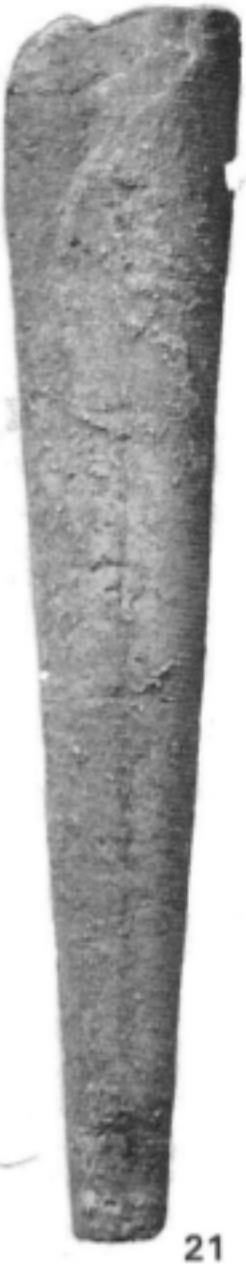
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PLATE 1–3

PLATE 1-4.—*Mooreoceras*

FIGURES 1-7, 9, 11, 14-16. *Mooreoceras normale* Miller, Dunbar & Condra.

1-3. Polished long (**1**, **3**) and end (**2**) views of incomplete hypotype showing some details of septa, sutures, and siphuncle, X2; Brush Creek unit, loc. MEco-1; OSU 29311.

4. Long view of exfoliated partial body chamber of hypotype showing a transverse constriction, X1; Brush Creek unit, loc. Ale-35; OSU 29422.

5. Polished long view of incomplete phragmocone of hypotype showing some details of septa and siphuncle, X1½; Columbiana unit, loc. Mg-2?; OSU 18704.

6. Long view of partially exfoliated incomplete body chamber of hypotype showing transverse constriction, X1; Brush Creek unit, loc. Cma-3; OSU 29321.

7. Long view of exfoliated incomplete hypotype showing part of phragmocone, body chamber, and transverse constriction, X1; Brush Creek unit, loc. Cma-3; OSU 29340.

9. Long view of exfoliated partial body chamber of hypotype showing transverse constriction, X1½; Columbiana unit, loc. Ss-6; OSU 29333.

11. End view of incomplete hypotype showing position of siphuncle, X1?; Brush Creek unit, loc. Ale-35; OSU 29422.

14. Polished long view of fragment of large hypotype showing traces of septa and siphuncle, X1; Columbiana unit, loc. Cs-9; OSU 29337.

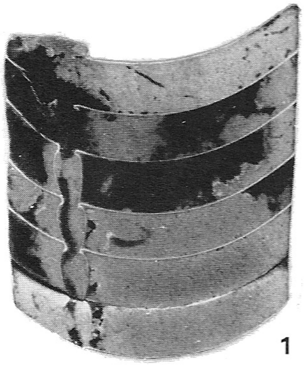
15. Long view of partially exfoliated incomplete hypotype showing traces of conchal furrow ridge and of sutures, X1; Putnam Hill unit, loc. Mg-4; OSU 19556.

16. Polished long view of fragment of phragmocone of large hypotype showing septa and position of siphuncle, X1; Columbiana unit, loc. Mg-2; OSU 29334.

8, 10, 12, 13. *Mooreoceras tuba* (Girty).

8. Long ventral view of body chamber and one cameral chamber of exfoliated incomplete hypotype showing apertural flare and possibly outline of hyponomic sinus, X1; Ames unit, loc. WV:Pr-1; OSU 29325.

10, 12, 13. End view (**10**, X2), showing position of siphuncle, and long views (**12**, **13**, both X1½), showing apertural flare, of two exfoliated imcomplete hypotypes; Washingtonville unit, loc. CSv-1; OSU 29323.



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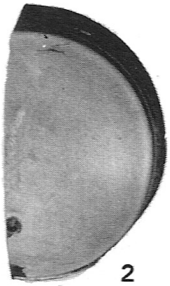

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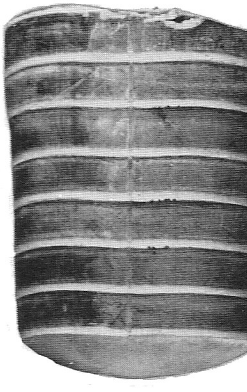

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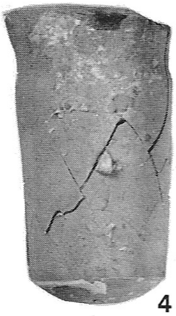

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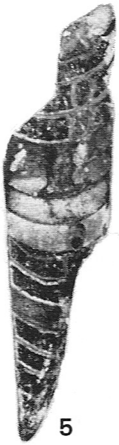

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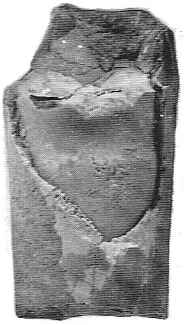

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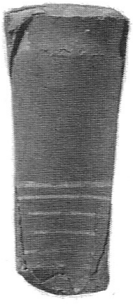

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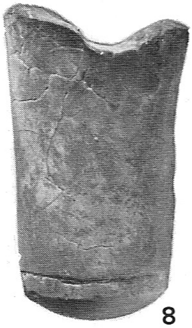

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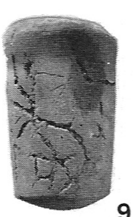

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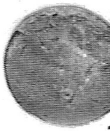

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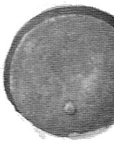

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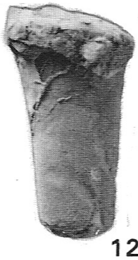

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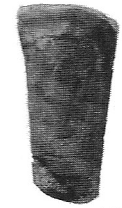

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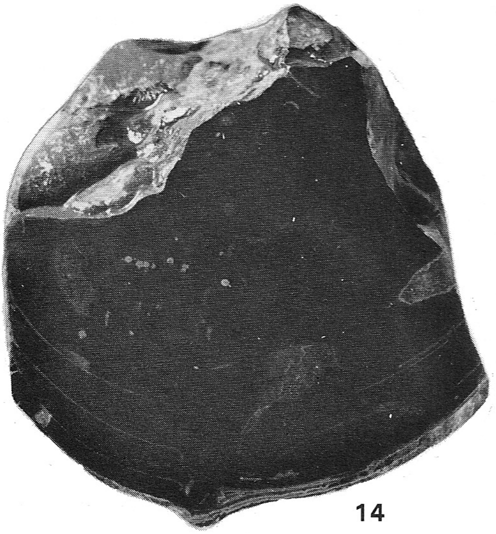

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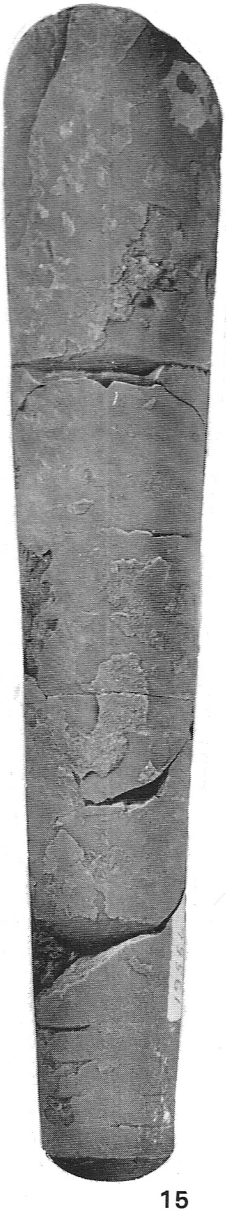

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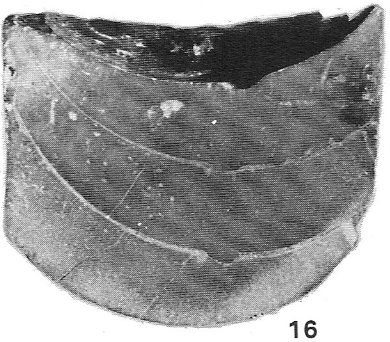

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PLATE 1–4

PLATE 1-5.—*Tainoceras*

FIGURES 1, 2, 4. *Tainoceras collinsi* Sturgeon, Windle, Mapes & Hoare. Views of incomplete holotype, X1; Ames unit, loc. WV:Mm-1; OSU 28826.

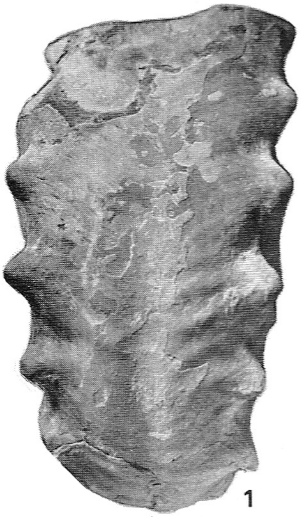
1. Ventral view showing median sulcus, oblique transverse ribs, and ventrolateral nodes.
2. Apicad transverse view showing whorl cross section, septum, position of siphuncle, and ventrolateral nodes.
4. Lateral view showing ventrolateral and umbilical nodes.

3, 5, 8. *Tainoceras marylandicum* (Lintz). Views of incomplete hypotypes, X1; Ames unit, loc. MD:Gtc-1.

3. Ventral view of fragmental specimen showing some details of median sulcus, oblique transverse ridges, and ventrolateral nodes; OSU 29327.
5. Lateral view of distorted specimen showing some features of ventrolateral and umbilical nodes and of lateral sutures; OSU 28823.
8. Lateral view of distorted specimen showing some details of coiling, umbilicus, and ventrolateral and umbilical nodes; OSU 28824.

6. *Tainoceras* sp. #1. Lateral view of incomplete specimen showing some details of ventrolateral and umbilical nodes and umbilical wall, X1; Ames unit, loc. Aa-47; OSU 28825.

7, 9. *Tainoceras* sp. #2. Ventral (**7**) and dorsal-end (**9**) views of exfoliated incomplete specimen showing some details of median ventral sulcus, oblique transverse ribs, and whorl cross section, X1; Ames unit, loc. Ad-13; OSU 28821.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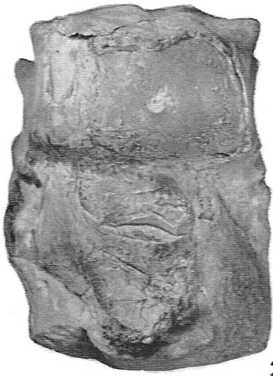
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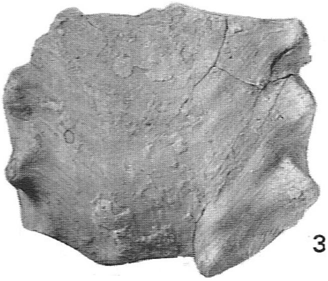
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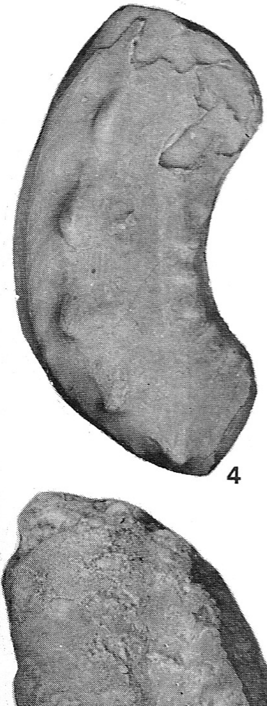
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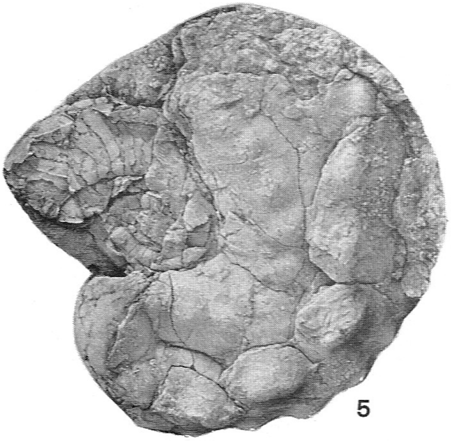
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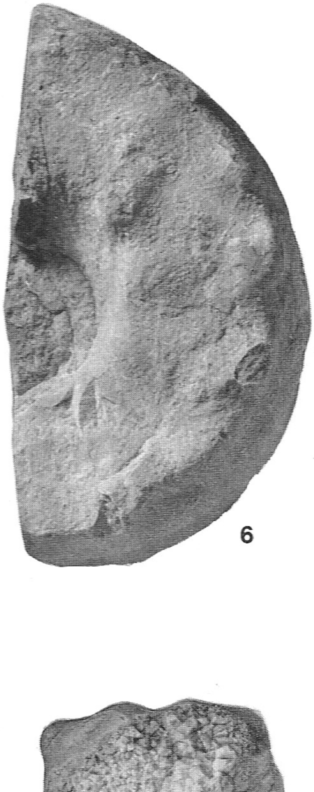
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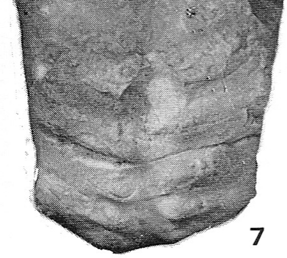
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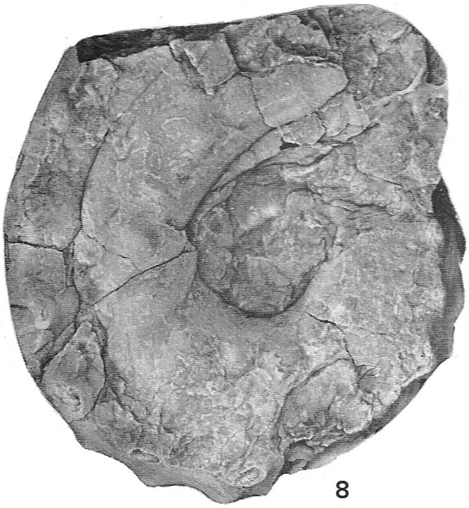
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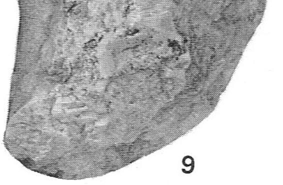
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PLATE 1–5

PLATE 1-6.—*Metacoceras*

FIGURES 1-3. *Metacoceras lambi* Sturgeon. Ventral (**1**), dorsal-end (**2**), and lateral (**3**) views of incomplete holotype showing features of venter, including sulcus, and of flanks and cross sections of whorl, X2 (approx.); Columbiana unit, loc. Mg-2; OSU 18721.

4-19. *Metacoceras latum* Sturgeon, Windle, Mapes & Hoare.

4, 5, 9. Orad-end (**4**), apicad-end (**5**), and ventral (**9**) views of incomplete paratype, X1; Washingtonville unit, loc. CAr-2; OSU 28898.

6, 10, 15, 19. Lateral (**6**, **15**) and ventral (**10**, **19**) views of three incomplete paratypes showing lateral (**6**, **15**) and ventral surface (**19**) details and ventral suture pattern (**10**), X2; Washingtonville unit, loc. CSv-1; OSU 28896.

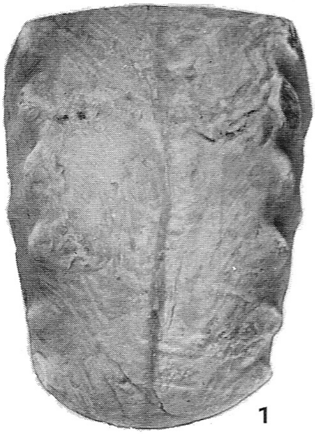
7. Lateral view of incomplete paratype showing surface details, X1; Columbiana unit, loc. Msp-2; OSU 28892.

8, 11, 12, 14. Lateral (**8**, **11**), dorsal-end (**12**), and ventral (**14**) views of incomplete holotype showing external features, dorsal impression, and cross section of whorl, X1; Washingtonville unit, loc. CAr-2; OSU 28913.

13, 18. Ventral (**13**, X1) and dorsal-end (**18**, X2) views of incomplete paratype showing details of venter and whorl cross section; Washingtonville unit, loc. CAr-2; OSU 28912.

16. Ventral view of very incomplete paratype showing small ventrolateral nodes, X1; Washingtonville unit, loc. CAr-2; OSU 28917.

17. Ventral view of incomplete paratype showing outline of ventral sinus, ventrolateral nodes, and secondary perforations, X2; Washingtonville unit, loc. MUmu-1; OSU 28897.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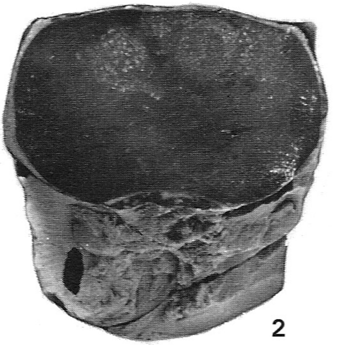
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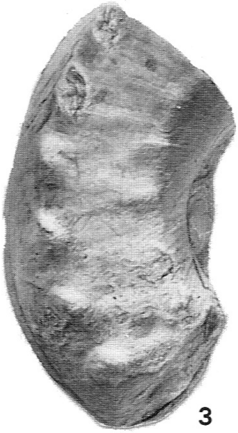
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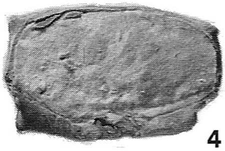
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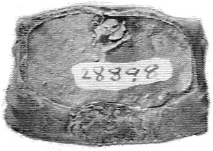

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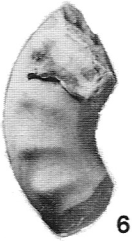
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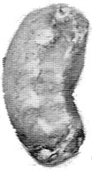
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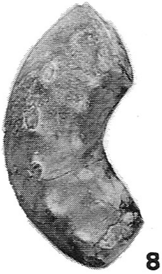
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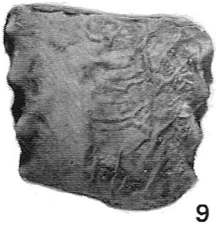
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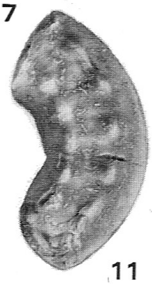
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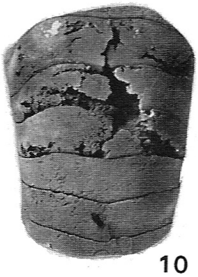
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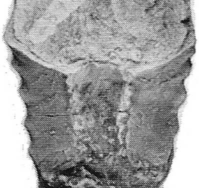
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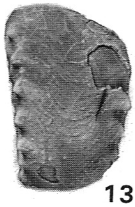
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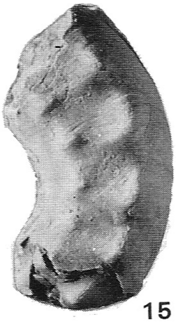
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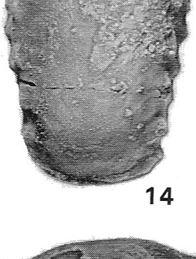
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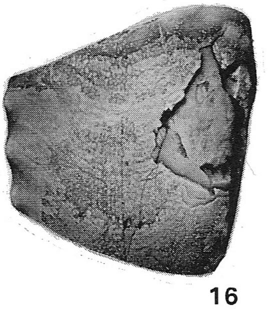
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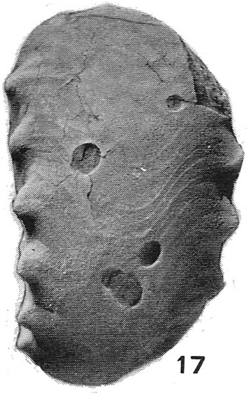
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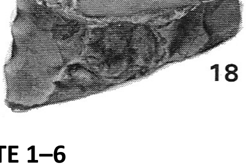
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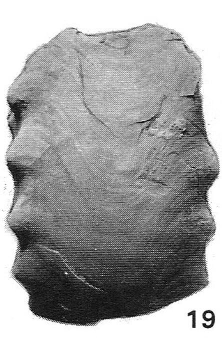
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PLATE 1–6

PLATE 1-7.—*Metacoceras mcchesneyi* Murphy

FIGURES 1-12. All X1; Brush Creek unit, loc. Cma-3.

1, 11. Lateral (**1**) and ventral (**11**) views of incomplete topotype showing coiling, umbilicus, and lateral, ventrolateral, and ventral surface features; OSU 28921.

2. Lateral view of fairly complete, slightly mashed, and exfoliated topotype showing coiling, umbilicus, ventrolateral nodes, lateral sutures, and part of body chamber; OSU 28924.

3. Lateral view of nearly complete but small topotype showing coiling, umbilicus, and lateral and ventrolateral surface features; OSU 28929.

4. Slightly oblique lateral view of nearly complete but small topotype showing coiling, umbilicus, and some features of flanks, venter, and ventrolateral shoulder; OSU 29264.

5. Ventral view of exfoliated incomplete topotype showing partial suture pattern; OSU 28923.

6. Ventral view of a partially exfoliated incomplete topotype showing thickness of test, ventrolateral nodes, and partial ventral sutures; OSU 28925.

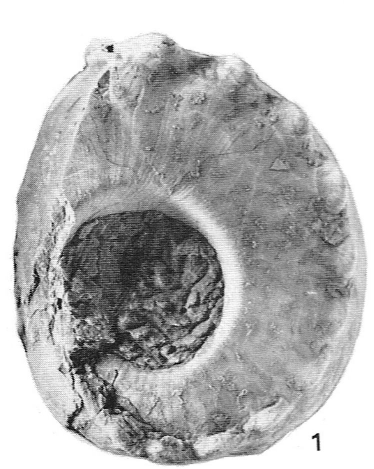
7. Polished lateral view of fairly complete topotype showing coiling and remnants of septa and siphuncle; OSU 28938.

8. Dorsal-end view of incomplete exfoliated topotype showing dorsal impression, umbilical wall, dorsal sutures, and whorl cross section; OSU 28927.

9. Oblique lateral view of incomplete topotype showing some lateral, ventral, and ventrolateral surface features; OSU 28934.

10. Polished lateral view of fairly complete topotype showing coiling, umbilical perforation, complete lack of septa, and partial filling of body chamber and much of phragmocone by fossil gastropod shells and rock fragments; OSU 28935.

12. Polished lateral view of nearly complete topotype showing coiling, umbilical perforation, almost complete destruction of septa, and two types of matrix filling interior of conch; OSU 28936.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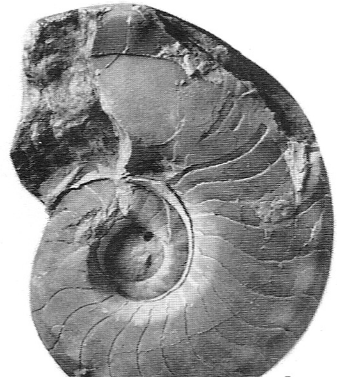
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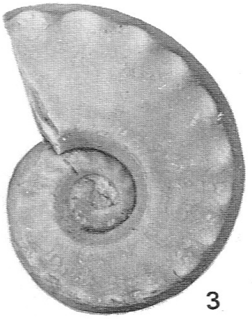
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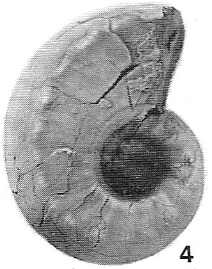
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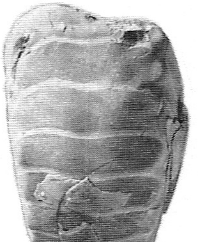
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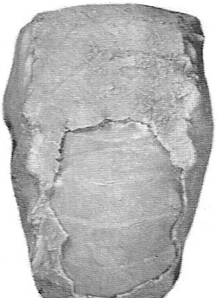
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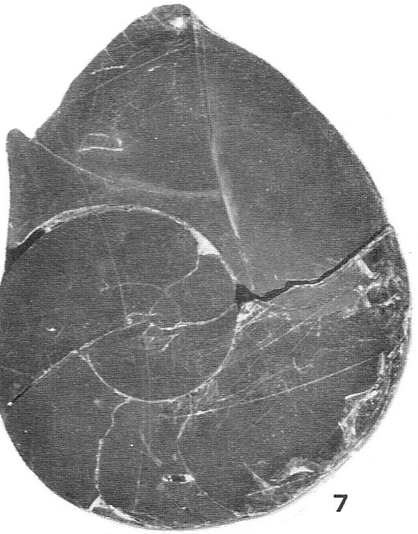
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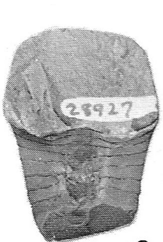

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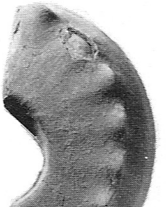
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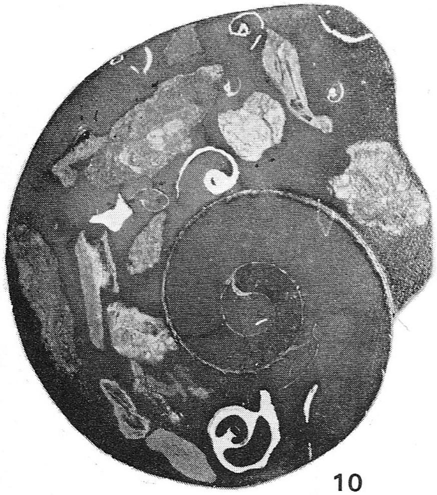
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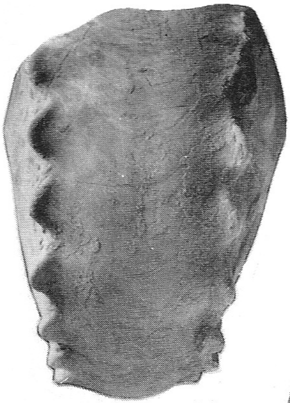
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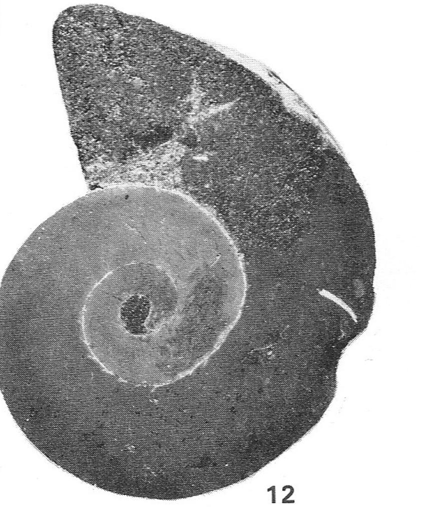
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PLATE 1–7

PLATE 1-8.—*Metacoceras*

FIGURES 1-3, 16. *Metacoceras* cf. *M. mcchesneyi* Murphy. Ventral (**1**, **2**), dorsal-end (**3**), and lateral (**16**) views of nearly complete transversely cut specimen, X1; Ames unit, loc. MUu-2; OSU 28932.

4-9. *Metacoceras clinocostatum* Sturgeon, Windle, Mapes & Hoare. X1; Brush Creek unit, loc. Aa-41.

  4. Lateral view of holotype; OSU 28971-A.

  5-9. Lateral (**7**-**9**), dorsal-end (**5**), and ventral (**6**) views of paratypes; OSU 28971-B.

10, 12. *Metacoceras mutabile* Miller & Owen. X1; Putnam Hill unit, loc. Mc-2.

  10. Lateral view of nearly complete hypotype; OSU 28893.

  12. Dorsal-end view of incomplete hypotype; OSU 28918.

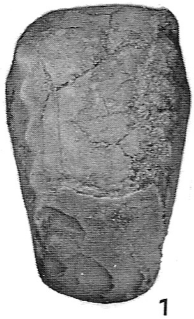
11, 13. *Metacoceras perelegans* Girty. X1; Columbiana unit.

  11. Cross-sectional view of cut and polished hypotype; loc. Cp-3?; OSU 19546.

  13. Lateral view of nearly complete hypotype; loc. Mg-10; OSU 18719.

14. *Metacoceras* sp. #2. Lateral view of incomplete specimen, X1; Brush Creek unit, loc. Ad-32; OSU 29137.

15. *Metacoceras tricarinatum tricarinatum* Sturgeon. Lateral view of incomplete syntype, X2; Putnam Hill unit, loc. Mg-4; OSU 18717.



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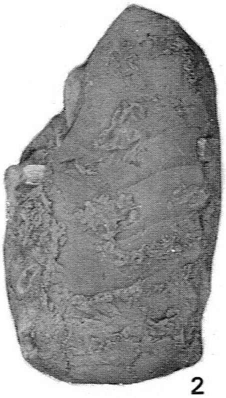

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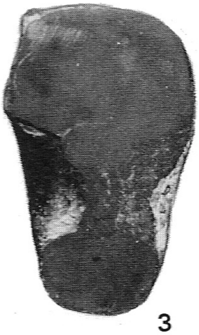

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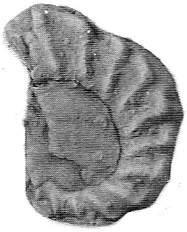

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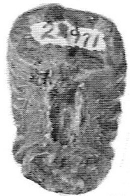

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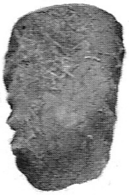

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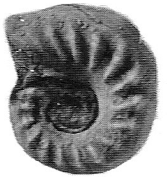

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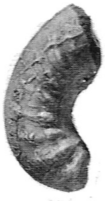

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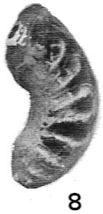

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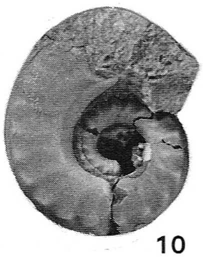

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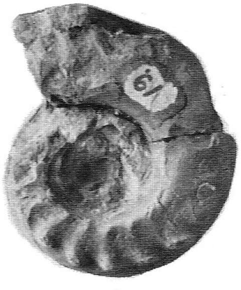

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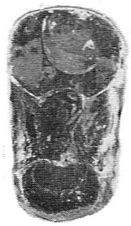

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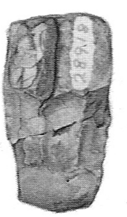

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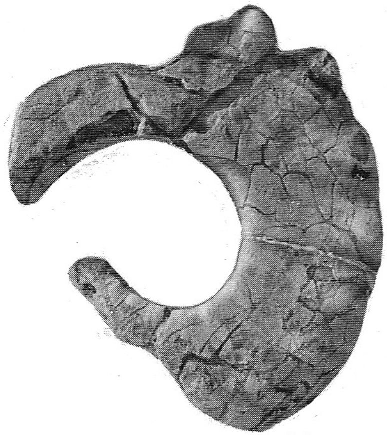

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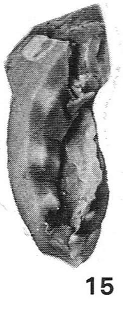

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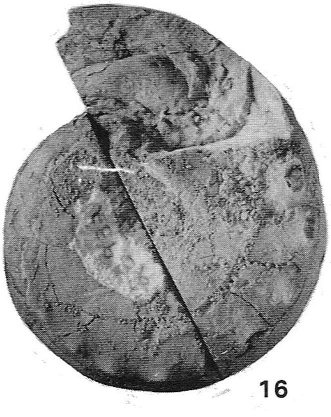

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PLATE 1–8

PLATE 1-9.—*Metacoceras*

FIGURES 1, 7. *Metacoceras* sp. #2. Lower Mercer unit.

- 1. Lateral view of incomplete and distorted specimen showing some external features, X1; loc. LIho-1; OSU 28960.
- 7. Lateral view of incomplete and fairly large specimen showing some external features, X2; loc. Vel-26; OSU 28959.

2, 6, 11. *Metacoceras tricarinatum tricarinatum* Sturgeon.

- 2, 6. Lateral (**2**) and ventral-end (**6**) views of incomplete but well-preserved hypotype showing coiling, umbilical perforation and carina, ventrolateral carinae and nodes, ventral surface, and whorl cross section, X2; Vanport unit, loc. Vel-24; OSU 28889.
- 11. Ventral view of small incomplete syntype showing venter and ventrolateral nodes, X1; Putnam Hill unit, loc. Mg-4; OSU 18717.

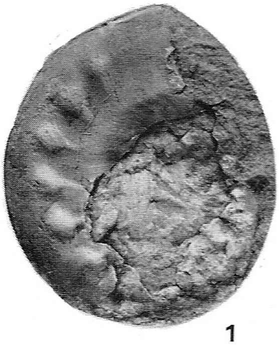
3, 4, 10, 12. *Metacoceras tricarinatum parvinodosum* Sturgeon. X2; Putnam Hill unit.

- 3, 4, 12. Ventrolateral (**3**, **4**) and lateral (**12**) views of incomplete syntypes showing carinae and small ventrolateral nodes; loc. Mg-4; OSU 18718.
- 10. Dorsal-end view of incomplete hypotype showing cross section of whorl and dorsal impression; loc. Td-4; OSU 28890.

5, 8, 13. *Metacoceras* sp. #3. Dorsal-end (**5**), lateral (**8**), and ventral (**13**) views of exfoliated, incomplete, only known specimen showing details of dorsal impression, umbilical wall, cross section of whorl, ventrolateral nodes, and venter, X2; Vanport unit, loc. Vel-19; OSU 28919.

9, 14-16. *Metacoceras* sp. #1, X1; Brush Creek unit.

- 9. Ventral view of incomplete specimen showing surface and ornament; loc. Cma-3; OSU 28956.
- 14-16. Lateral (**14**), ventral (**15**), and end (**16**) views of incomplete specimen showing surface of flank and venter, ventrolateral nodes, and cross section of whorl; loc. Ale-35; OSU 28955.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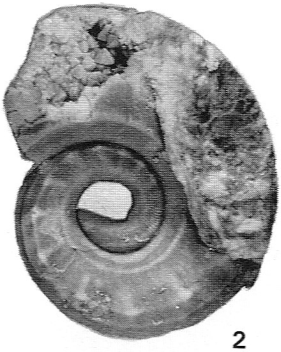
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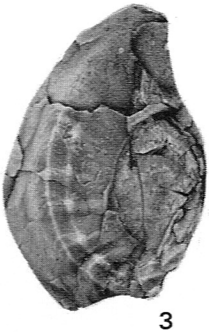
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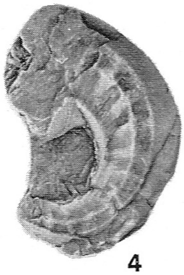
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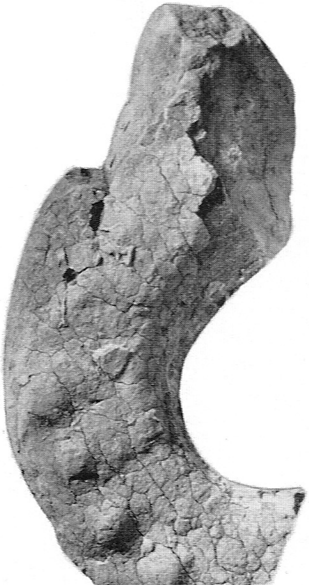
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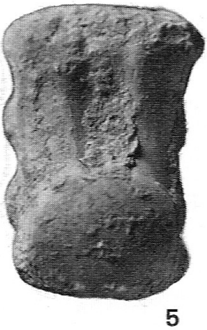
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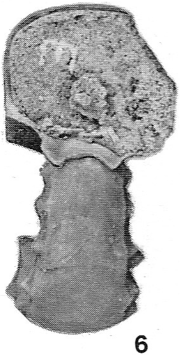
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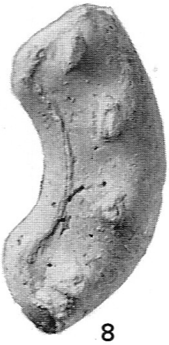
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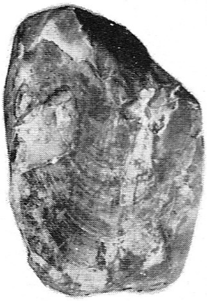
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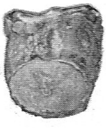
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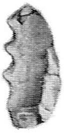
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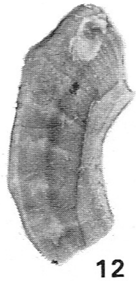
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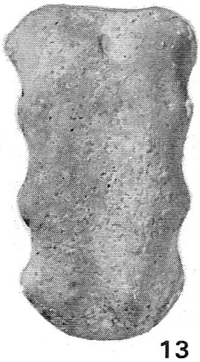
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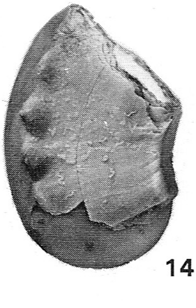
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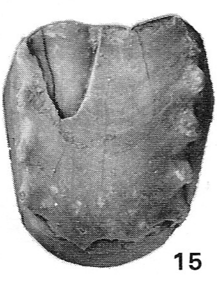
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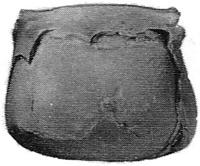
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PLATE 1–9

PLATE 1-10.—*Parametacoceras*

FIGURES 1-5, 7, 8. *Parametacoceras bellatulum* Miller & Owen. X2 (several approx.); Cherokee Formation, Henry County, Missouri.

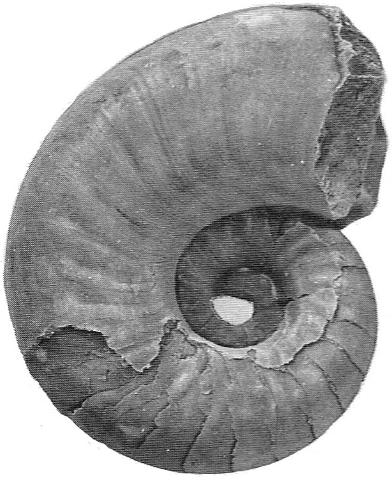
1, 4, 7. Lateral (**1**), apertural-ventral (**4**), and ventral (**7**) views of nearly complete holotype showing ornament, umbilicus, body chamber, and sutures; loc. MO:Hbo-1; SUI 13408.

2, 8. Cross-sectional views of cut and polished paratypes showing whorl profiles, septa, and siphuncle; loc. uncertain; SUI 13412.

3. Lateral view of partially exfoliated nearly complete paratype showing portions of suture and surface ornament; loc. MO:Hbo-3; SUI 13414.

5. Longitudinal cut and polished view of nearly complete paratype showing different matrix in body chamber and phragmocone, septa, siphuncle, and umbilical perforation; loc. uncertain; SUI 13412.

6, 9. *Parametacoceras* cf. *P. bellatulum* Miller & Owen. Lateral views of two incomplete specimens showing some details of ornament, X2 (approx. for **6**); Putnam Hill unit, loc. Mg-4; OSU 18725.



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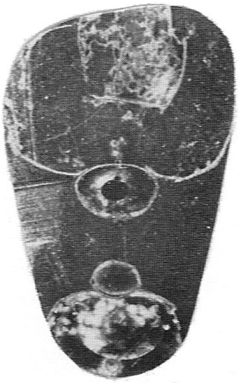

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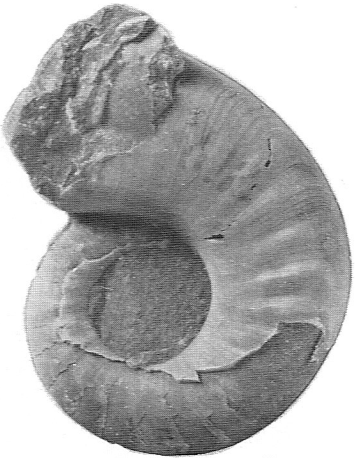

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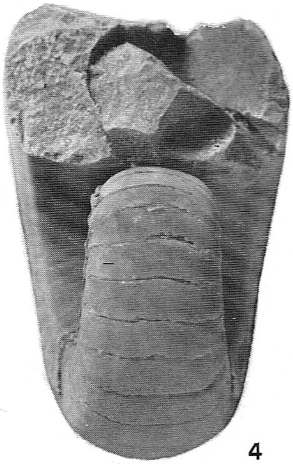

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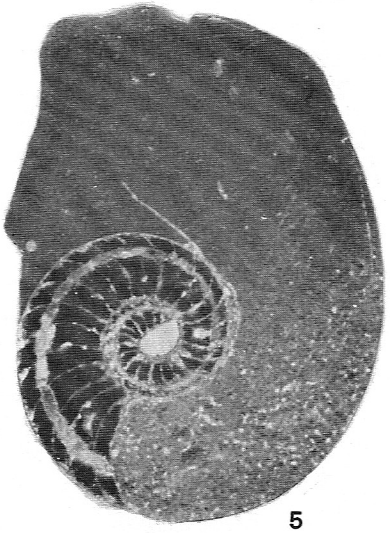

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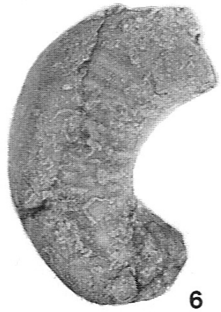

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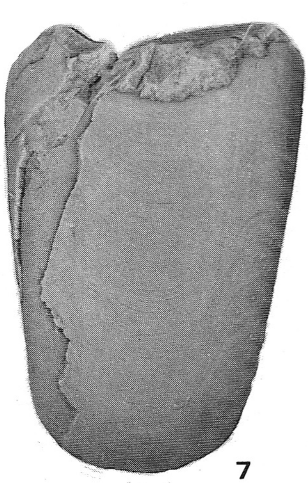

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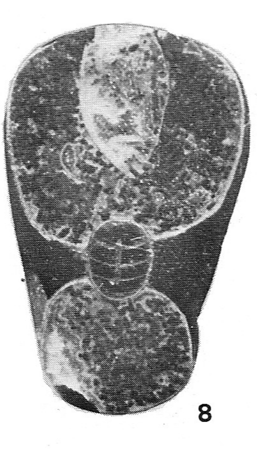

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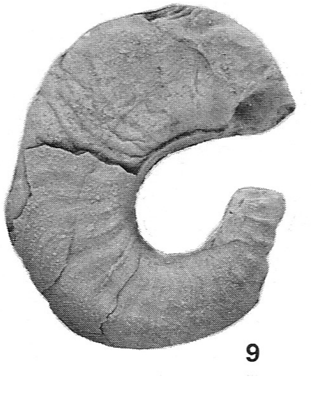

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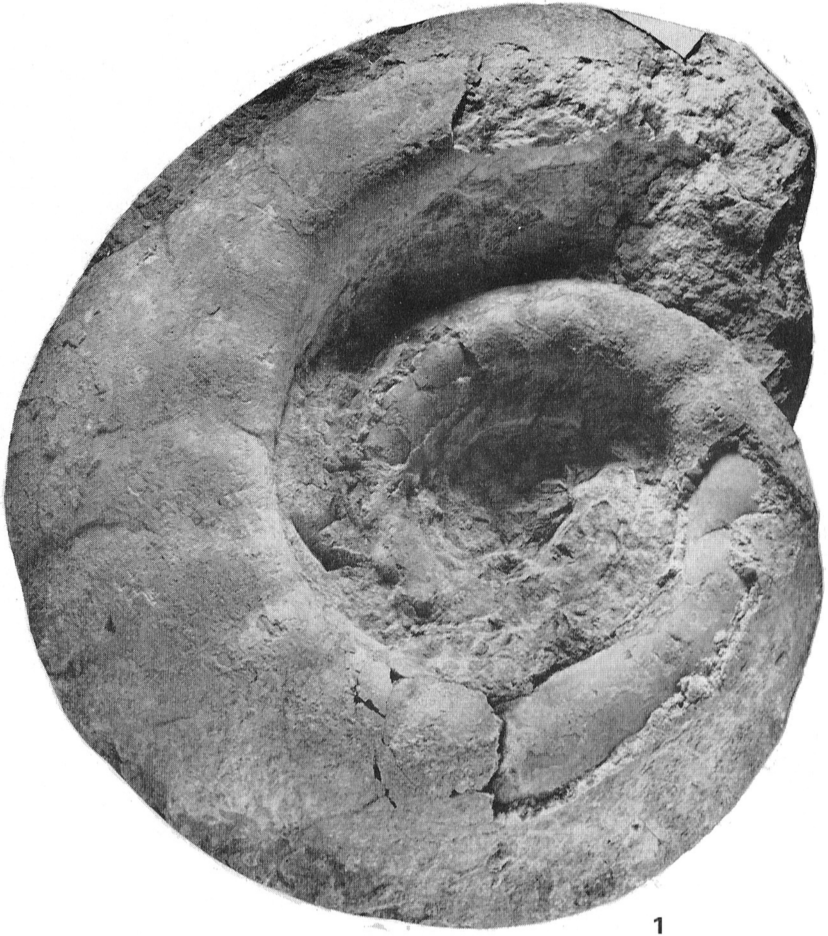
PLATE 1–10

PLATE 1-11.—*Endolobus*

FIGURE 1. *Endolobus ortoni* (Whitfield). Lateral view of nearly complete holotype showing coiling, thickness of test, and some surface features, X1; Lower Mercer unit, loc. SUsp-2; AMNH 7426 G.

2. *Endolobus* cf. *E. forbesianus* (McChesney). Lateral view of incomplete and broken specimen showing some details of coiling, test, and surface, X1; Lower Mercer unit, loc. Sb-1; OSU 28867.



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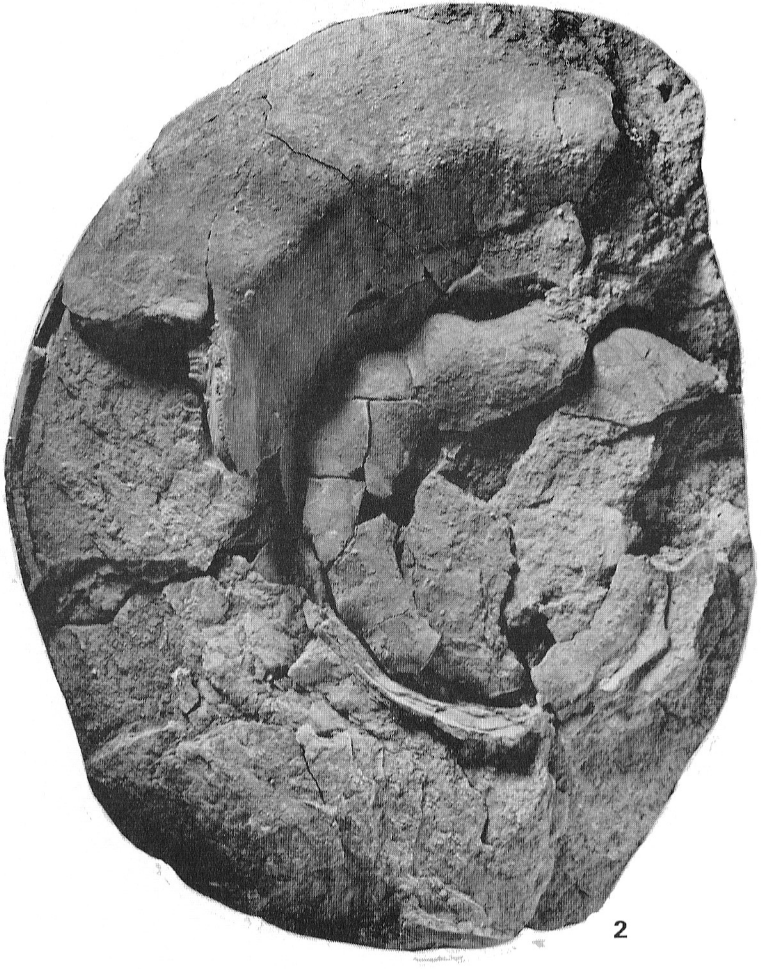

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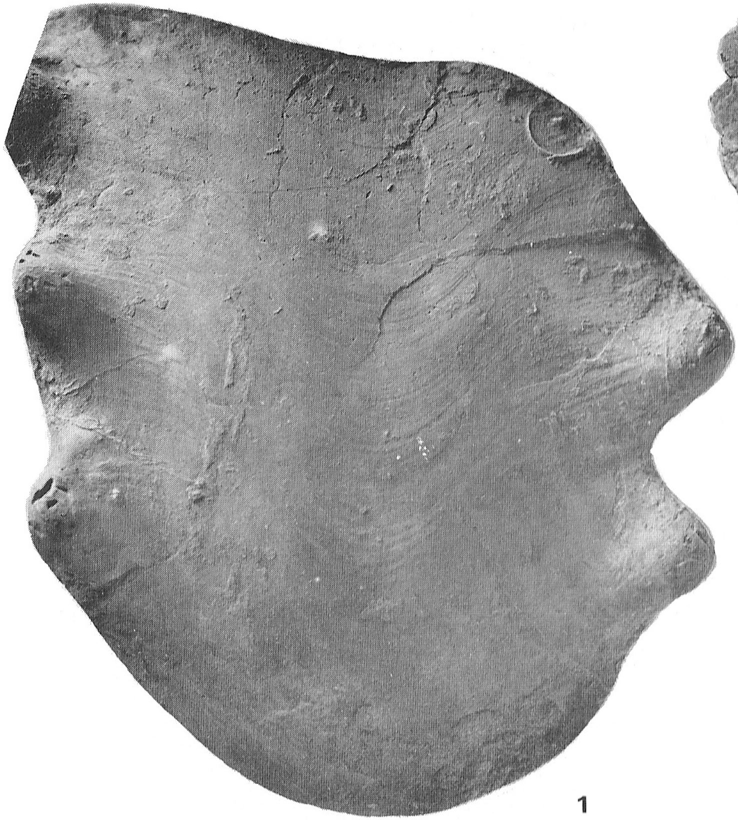
PLATE 1–11

PLATE 1-12.—*Endolobus* and *Latitemnocheilus*

FIGURE 1. *Latitemnocheilus* cf. *L. latus* (Meek & Worthen). Ventral view of incomplete specimen showing ventral surface features, ventrolateral nodes, including two with bore holes, and a single adhering specimen of the inarticulate brachiopod *Crania modesta* White & St. John, X1; Putnam Hill unit, loc. Ms-3; OSU 28873.

2. *Endolobus* cf. *E. forbesianus* (McChesney). Lateral view of nearly complete but slightly distorted specimen showing coiling and external features, X1; Putnam Hill unit, loc. Vel-15; OSU 28866.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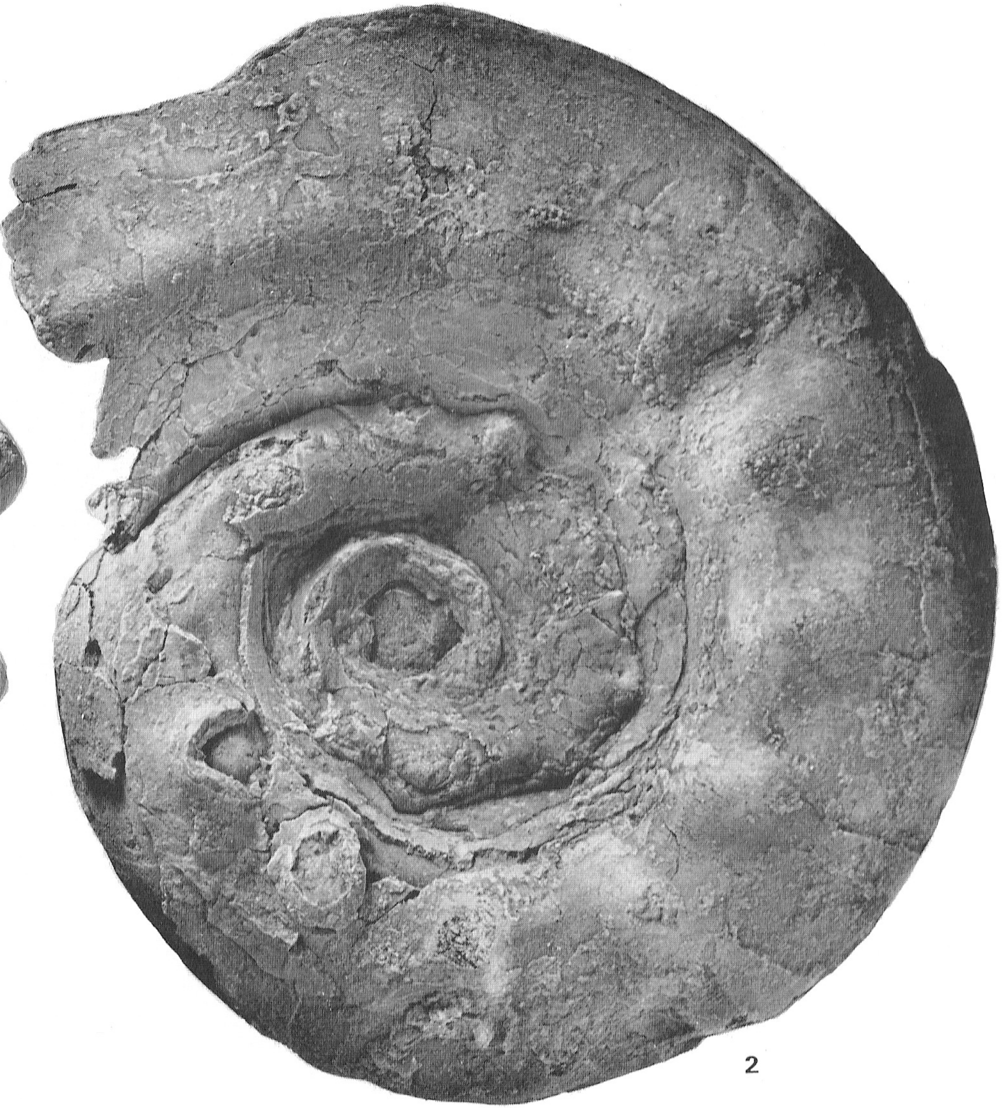
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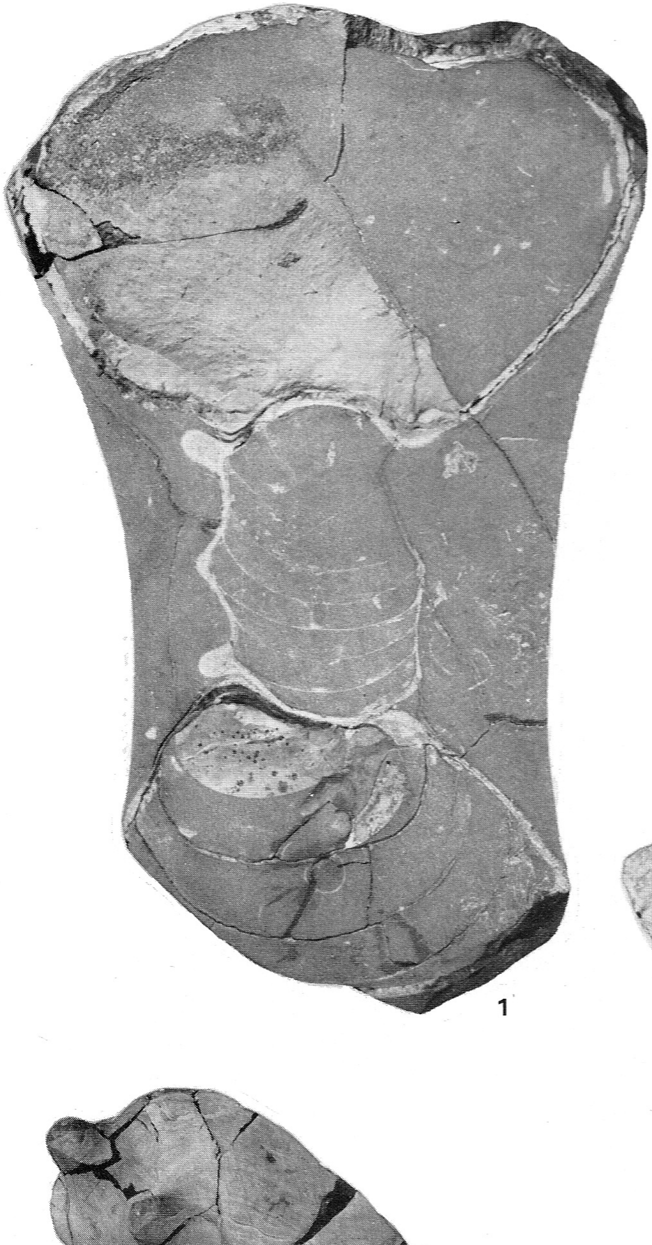
PLATE 1–12

PLATE 1-13.—*Temnocheilus annulonodosus* Sturgeon, Windle, Mapes & Hoare

FIGURES 1-5. All X1; Putnam Hill-Vanport units undifferentiated.

1. Polished transverse sectional view of incomplete paratype showing some details of whorl section, umbilicus, septa, and nodes; loc. MUho-3; OSU 28872.
2. Ventrolateral view of fragmental paratype showing nodes and surface features; loc. Td-4; OSU 28881.

3-5. Ventral (**3**), end (**4**), and lateral (**5**) views of incomplete holotype showing surface features and cross section of whorl; loc. MUho-3; OSU 28880.



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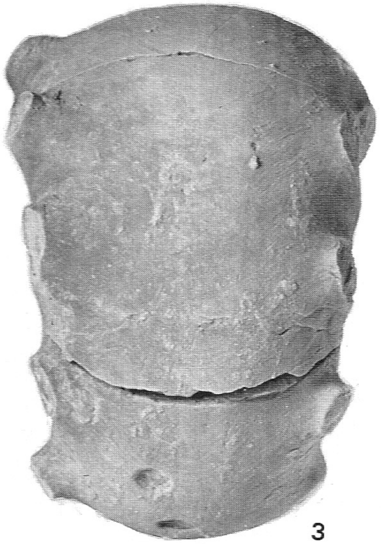

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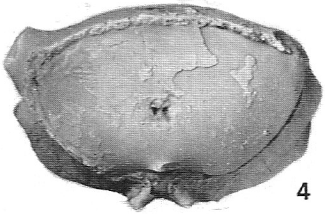

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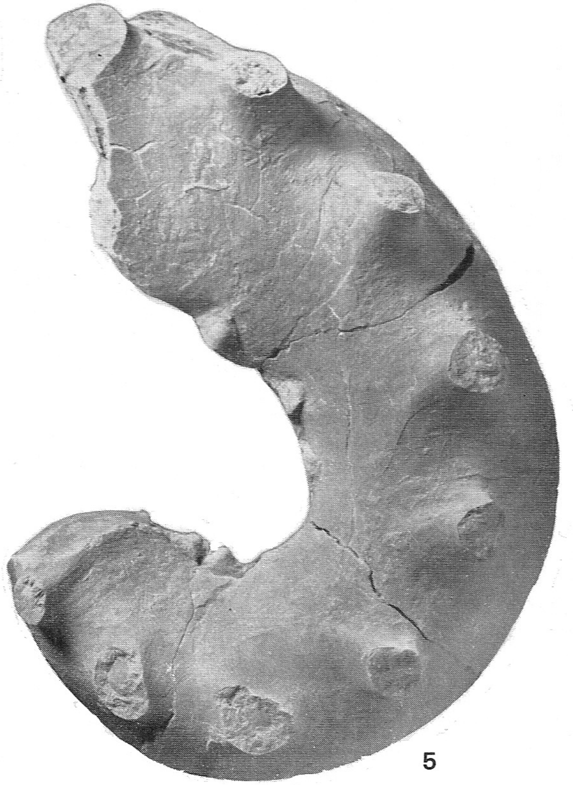

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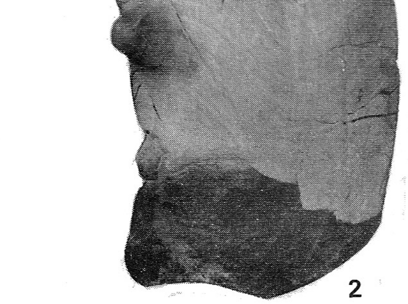

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PLATE 1–13

PLATE 1-14.—*Latitemnocheilus*, *Mahoningoceras*, and *Temnocheilus*

FIGURE 1. *Temnocheilus annulonodosus* Sturgeon, Windle, Mapes & Hoare. Polished long view of incomplete paratype showing some details of septa and siphuncle, X1; Columbiana unit, loc. Mg-10; OSU 28907.

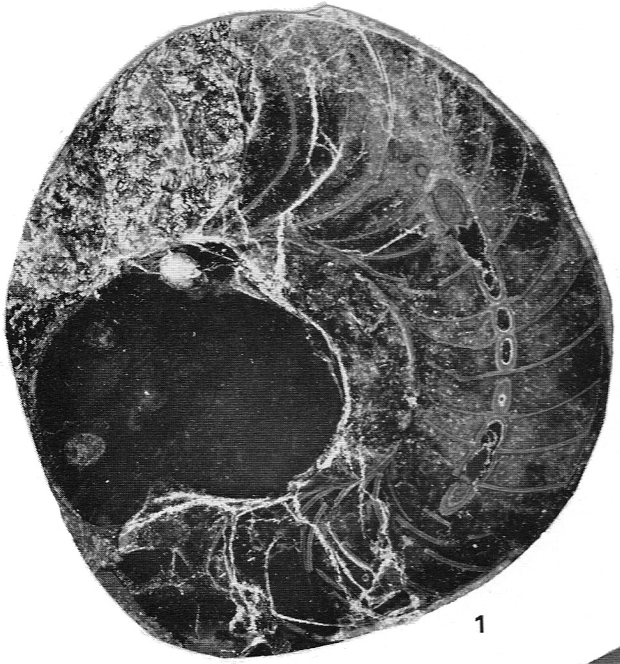
2-4. *Temnocheilus quinqueliratus* Sturgeon. X1.

  2. Lateral view of doubtful incomplete hypotype showing details of test and ventrolateral nodes; Putnam Hill unit, loc. Mc-2; OSU 28879.

  3, 4. Lateral (**3**) and ventral (**4**) views of incomplete exfoliated holotype showing some details of sutures, ventral and ventrolateral ridges, and ventrolateral nodes; Vanport unit, Tl-1; OSU 18713.

5. *Mahoningoceras pottsvillense* (Morningstar). Ventral-end view of hypotype (formerly holotype of *Temnocheilus searighti* Unklesbay & Palmer) showing initial longitudinal lines, X1; Burgner Formation, loc. MO:JAj-1; UM 13997.

6. *Latitemnocheilus* cf. *L. latus* (Meek & Worthen). Ventral view of incomplete specimen showing surface features of venter and ventrolateral nodes, X1; Putnam Hill unit, loc. Ty-3; OSU 29248.



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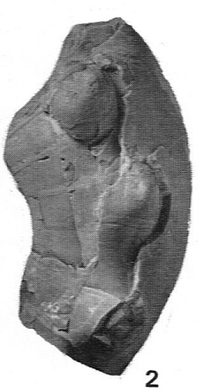

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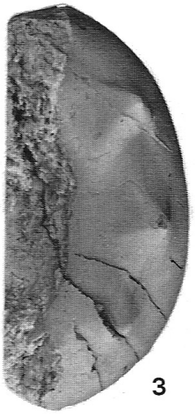

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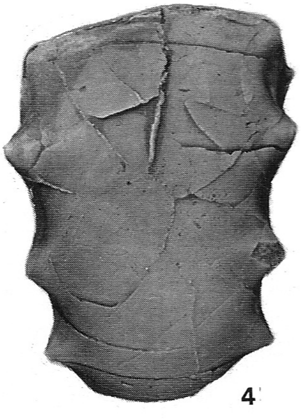

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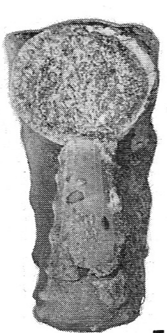

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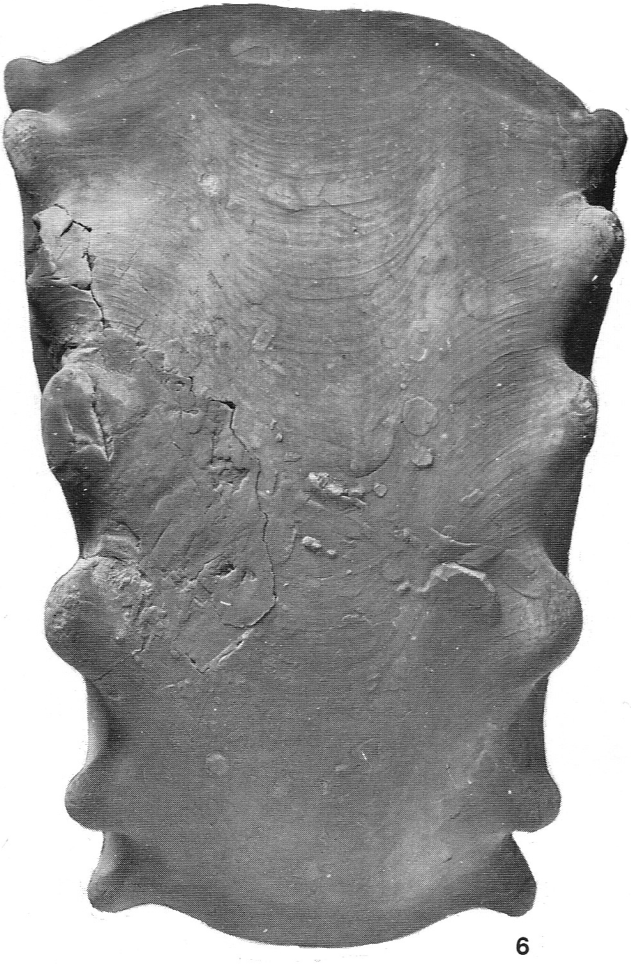

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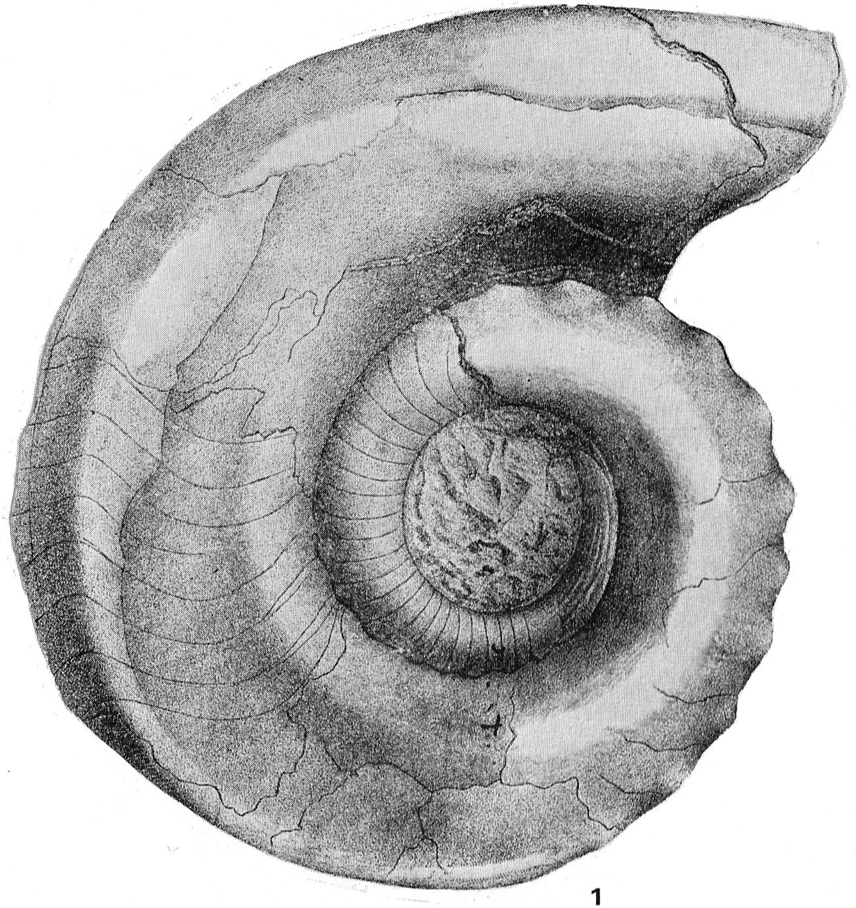
PLATE 1–14

PLATE 1-15.—*Mahoningoceras subquadrangulare* (Whitfield)

FIGURES 1, 2. Line drawing (**1**, from Whitfield, 1882) and photograph (**2**) of lateral view of largely exfoliated holotype showing details of coiling, septa and sutures, ventrolateral nodes, and initial longitudinal lines, X1; Lower Mercer unit; loc. Mc-4; AMNH 7425 G.



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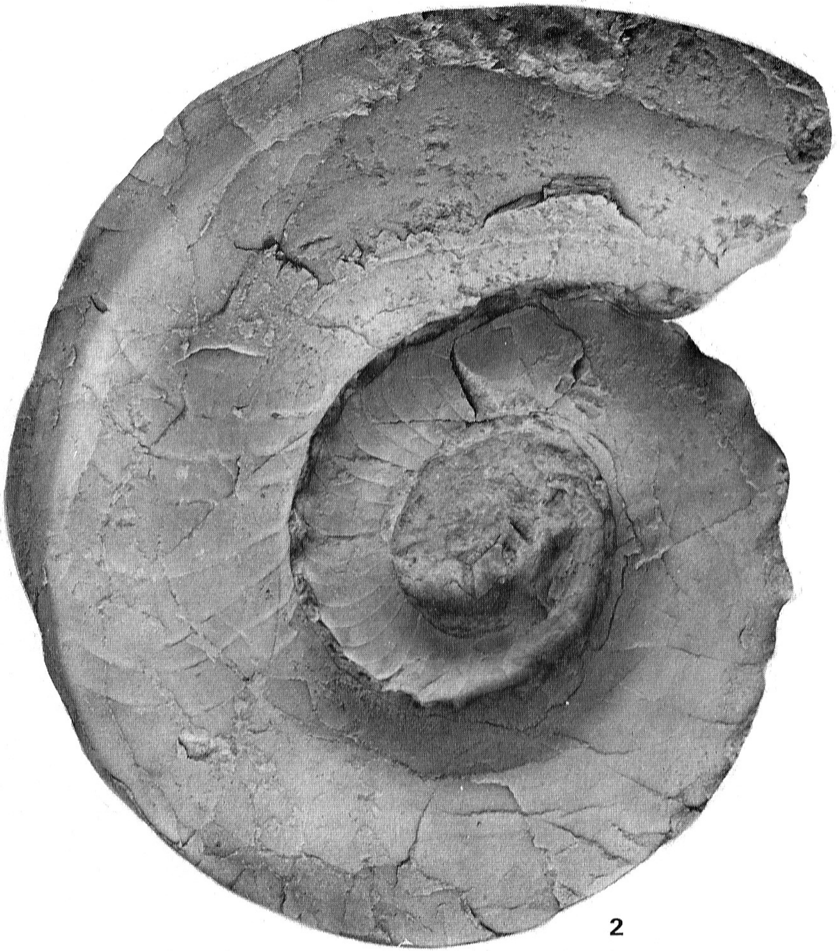

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PLATE 1–15

PLATE 1-16.—*Latitemnocheilus*

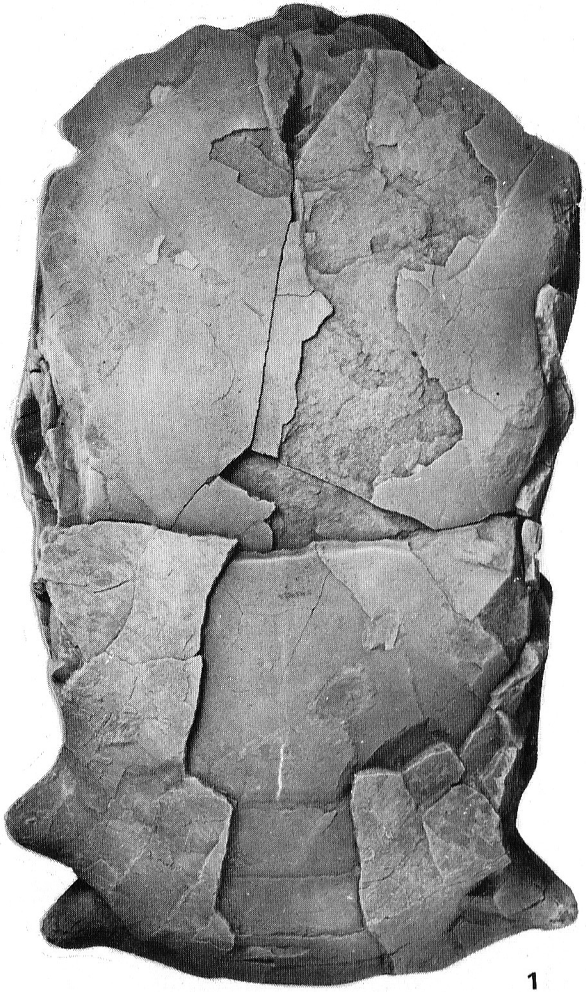
FIGURE 1. *Latitemnocheilus* sp. Ventral view of partially exfoliated incomplete specimen showing some details of exterior, body chamber, and sutures, X1; Putnam Hill-Vanport units undifferentiated; loc. MUho-3; OSU 28871.

2, 3. *Latitemnocheilus bellicosus* (Morton). X$^{2}/_{3}$ (approx.); Vanport unit; loc. MUsp-1; present repository unknown. Both from Morton (1836).

2. Oblique lateral-transverse view of one of Morton's figured specimens showing external and cross-section details.

3. Lateral view of one of Morton's figured specimens showing coiling and external features, including numerous ventrolateral nodes.

4, 5. *Latitemnocheilus medioventralis* (Sturgeon). End (**4**) and ventral (**5**) views of incomplete lectotype, X1; Columbiana; loc. Mg-2; OSU 18715.



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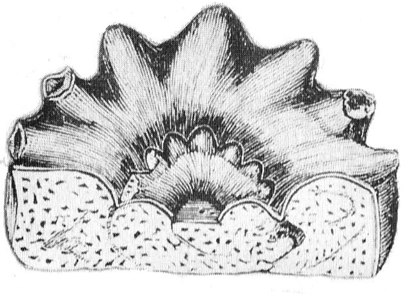

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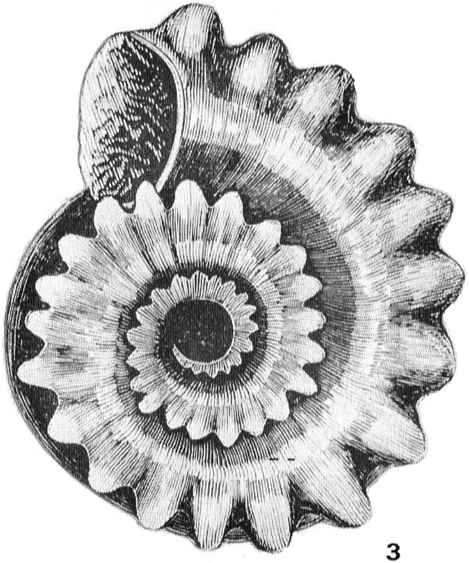

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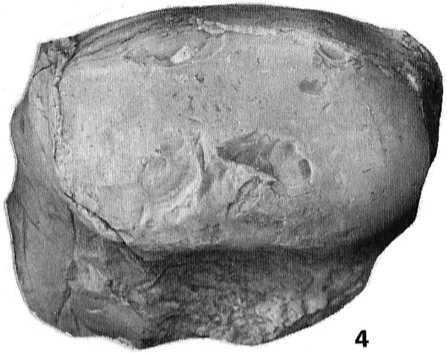

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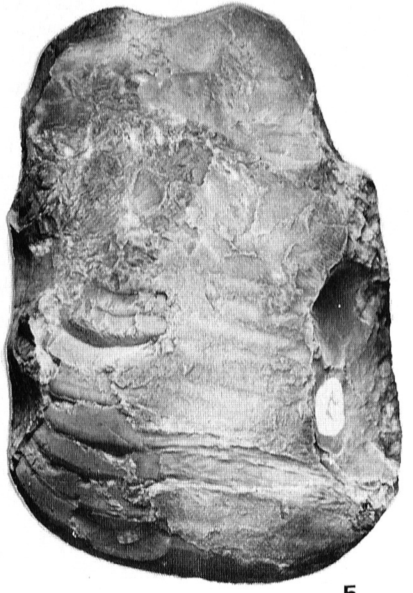

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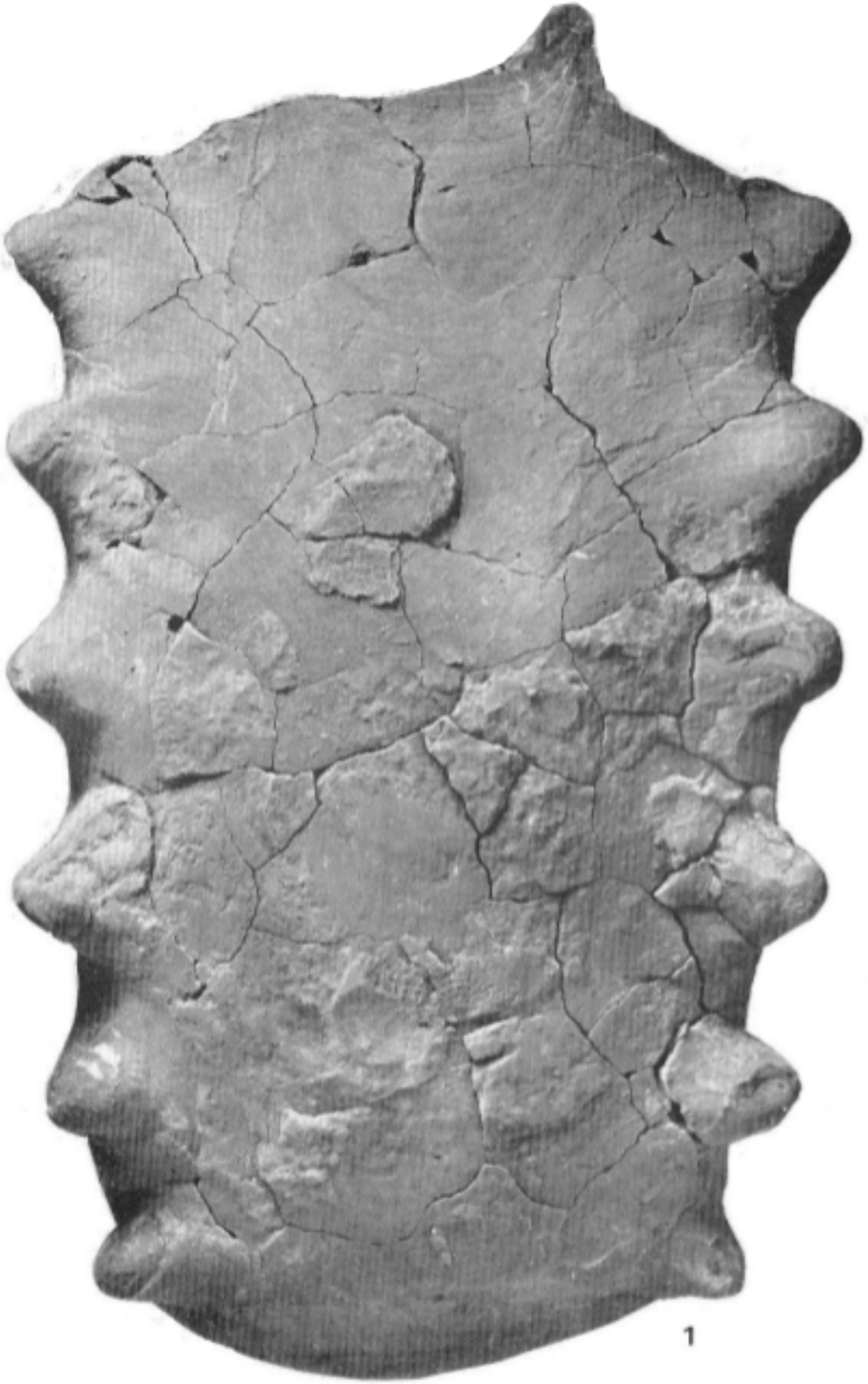
PLATE 1–16

PLATE 1-17.—*Latitemnocheilus harneri* (Miller & Owen)

FIGURES 1, 2. X1; Cherokee Formation.

1. Ventral view of incomplete and slightly distorted paratype showing external features; loc. MO:Vo-1; SUI 6172.
2. Lateral view of incomplete and somewhat distorted holotype showing coiling and external features, including initial longitudinal lines; loc. MO:Hfc-1; SUI 13398.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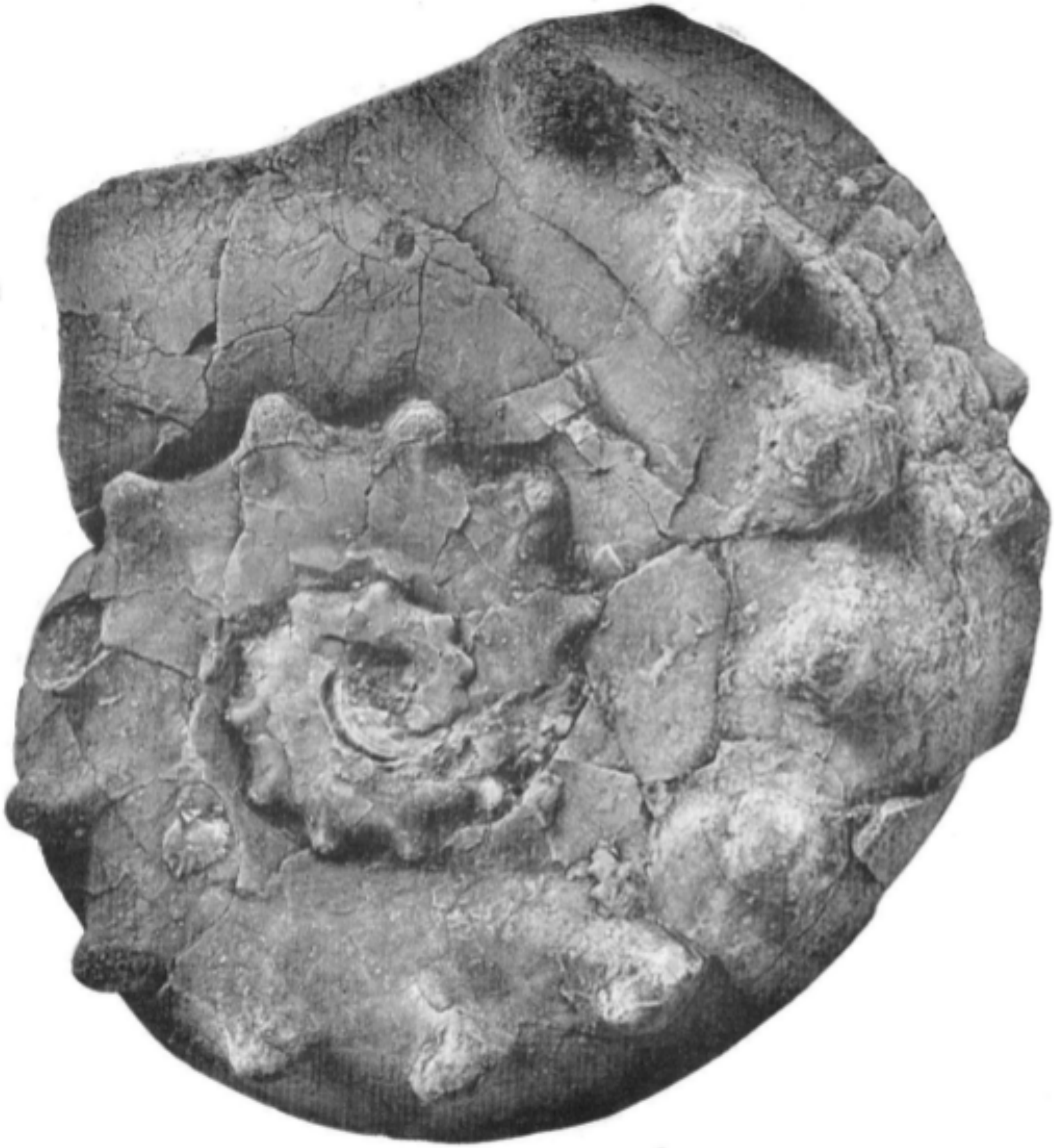
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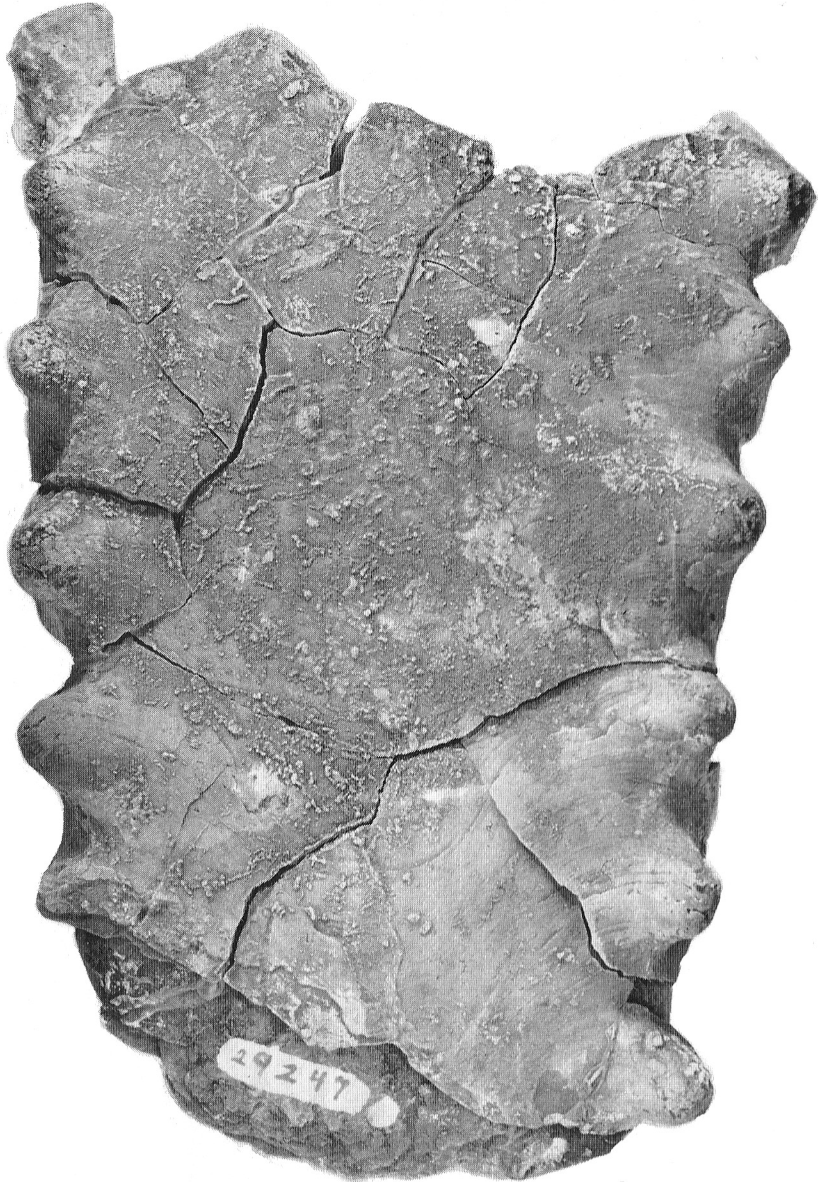
PLATE 1-18.—*Latitemnocheilus* cf. *L. harneri* (Miller & Owen)

FIGURES 1, 2. Ventral views of two incomplete specimens showing external features, X1; Putnam Hill unit, loc. Ms-3; OSU 29247 (**1**) and 28884 (**2**).



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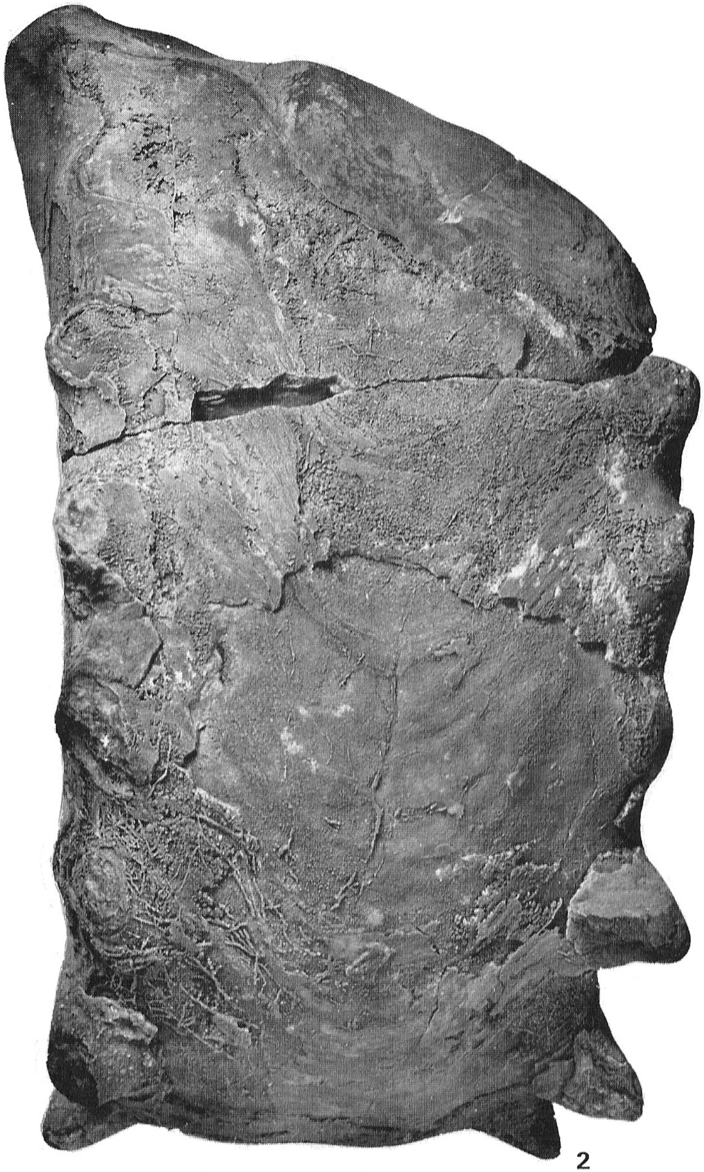

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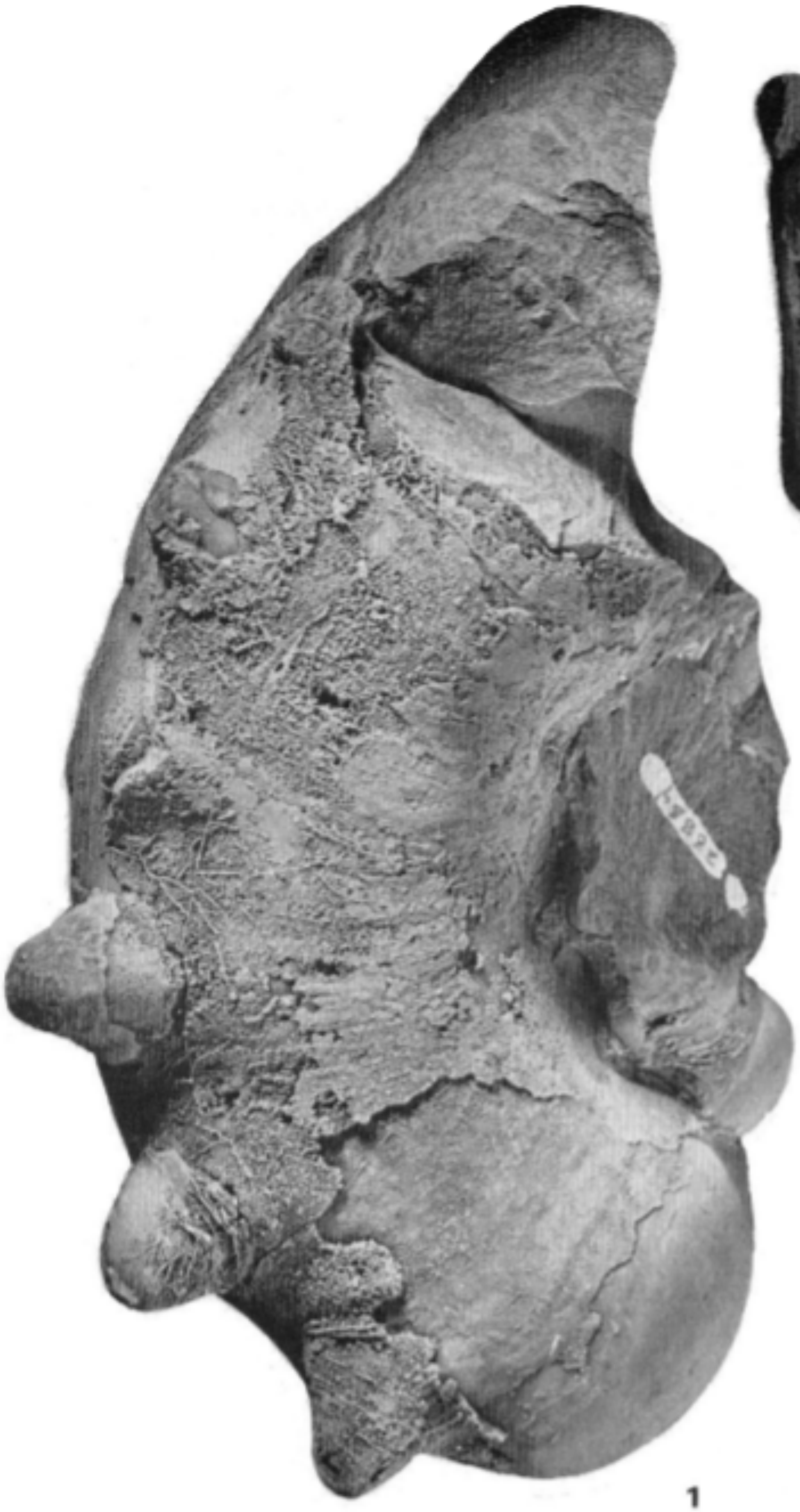
PLATE 1–18

PLATE 1-19.—*Latitemnocheilus*

FIGURES 1-3. *Latitemnocheilus* cf. *L. harneri* (Miller & Owen). Lateral (**1**, **3**) and end (**2**) views of large incomplete specimen showing some details of surface features, septa, annular lobe (**2**), and siphuncle, X1; Putnam Hill unit, loc. Ms-3; OSU 28884.

4. *Latitemnocheilus* cf. *L. johnsoni* (Miller, Dunbar & Condra). Ventral view of incomplete flattened specimen showing external features, X1; Lowellville (Poverty Run) unit, loc. Tfr-1; OSU 29315.



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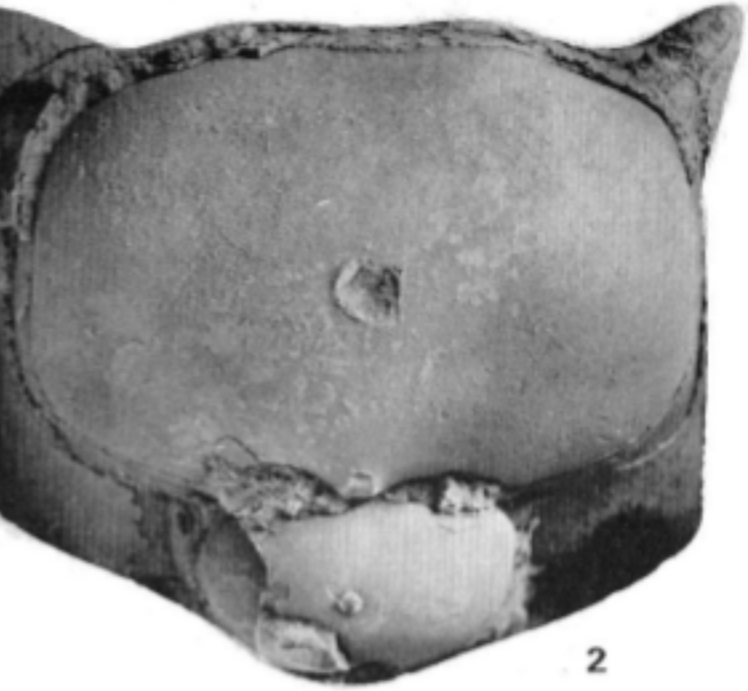

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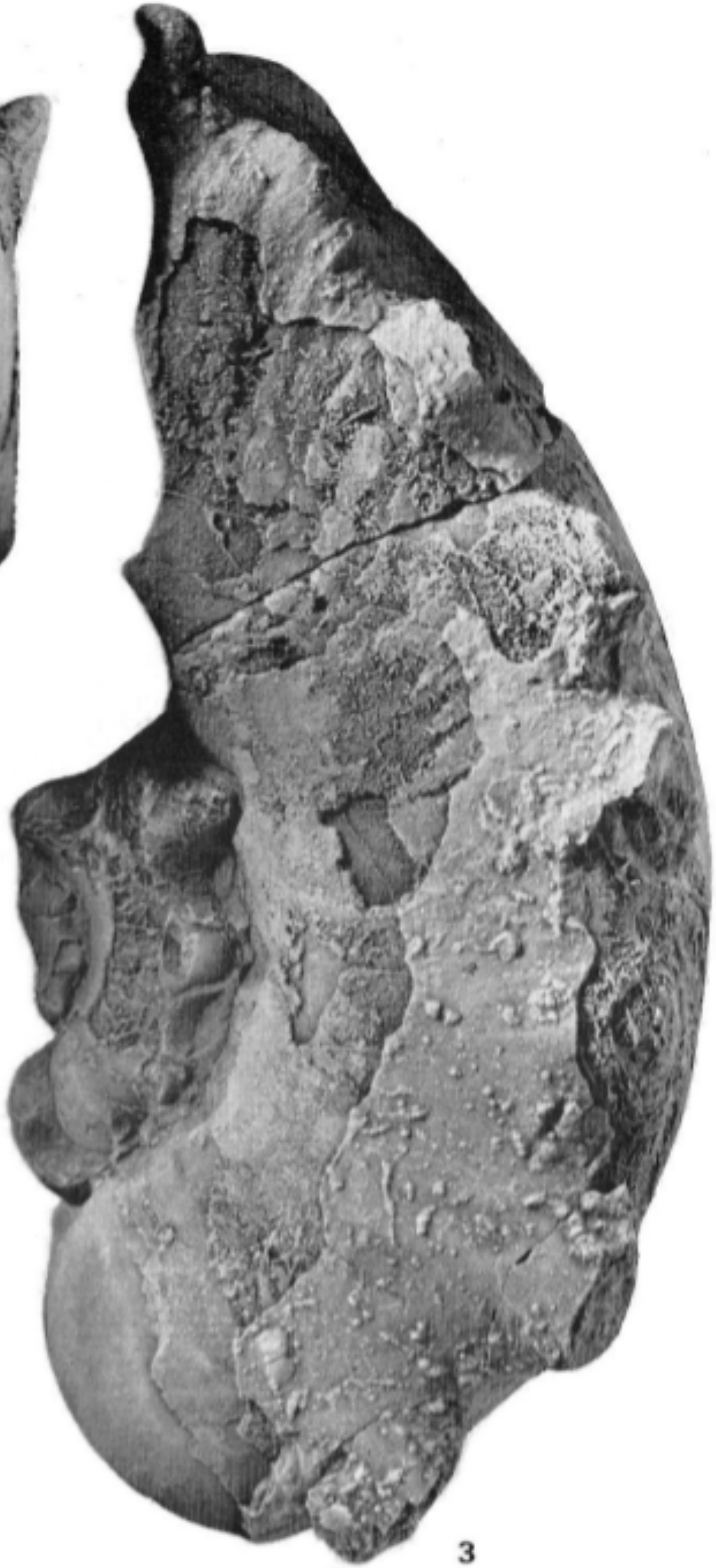

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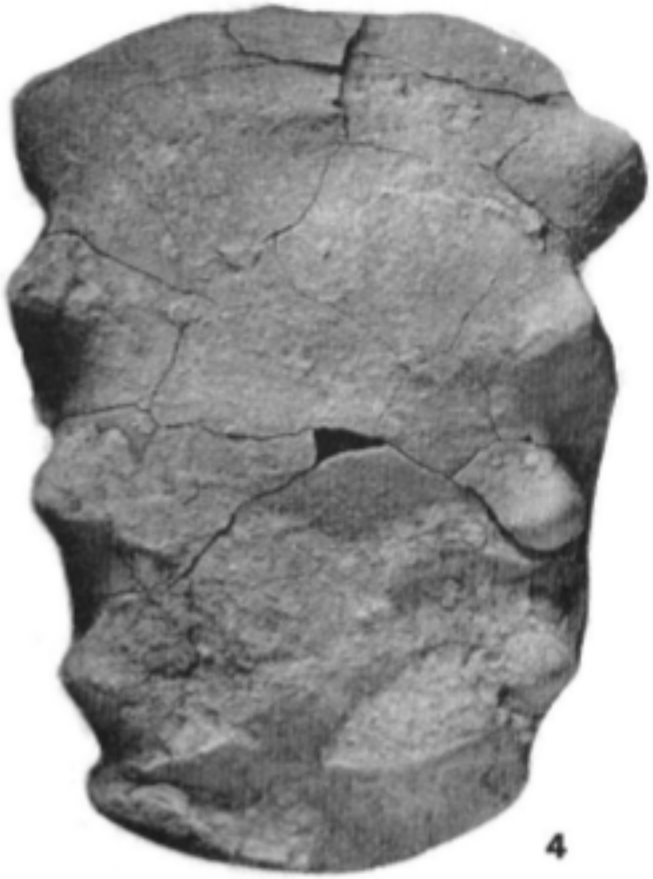

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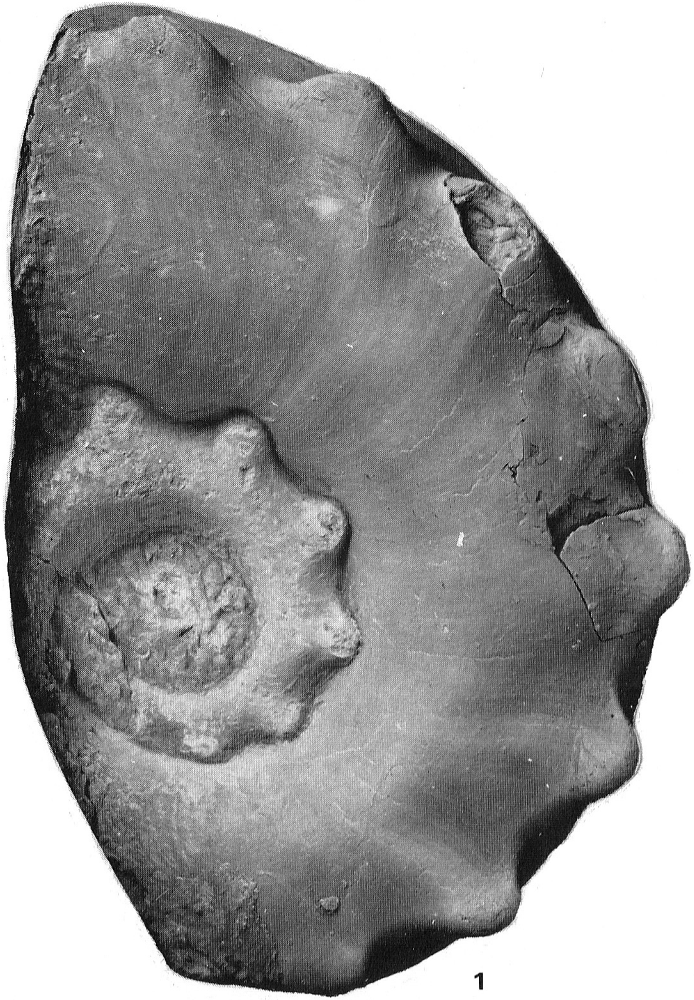
PLATE 1–19

PLATE 1-20.—*Latitemnocheilus latus* (Meek & Worthen)

FIGURES 1, 2. Lateral (**1**) and oblique ventrolateral (**2**) views of holotype showing some details of coiling, nodes, and other surface features, X1; Seville Limestone, loc. IL:RIh-1; UI X 438A.



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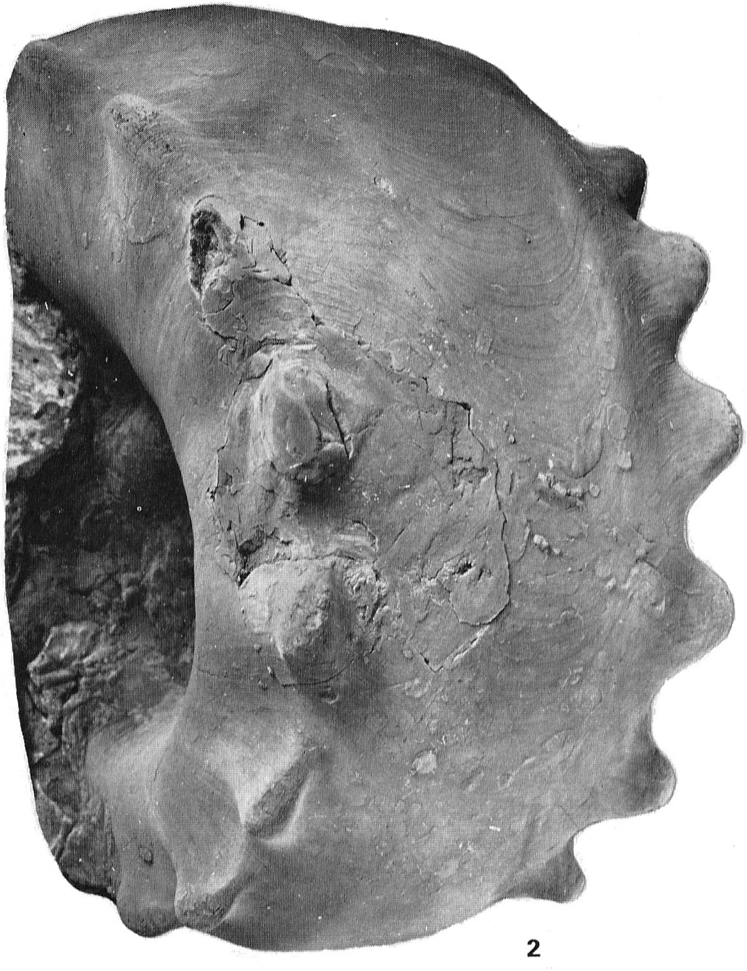

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PLATE 1–20

PLATE 21.—*Latitemnocheilus*, *Mahoningoceras*, and *Temnocheilus*

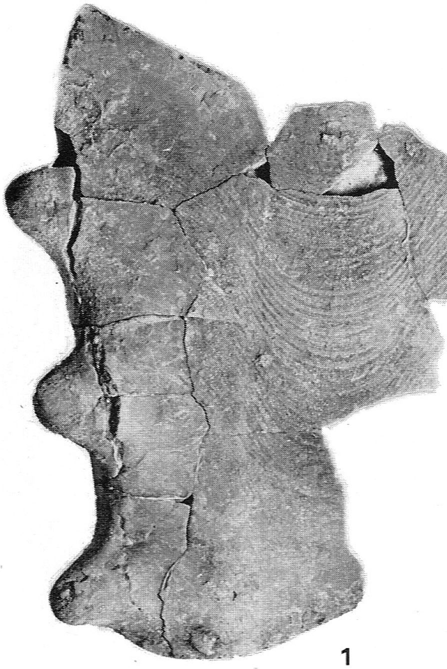
FIGURE 1. *Latitemnocheilus*? sp. #1. Ventral view of fragmental specimen showing surface features, X1; Washingtonville unit, loc. Ty-1; OSU 28904.

2. *Latitemnocheilus* cf. *L. johnsoni* (Miller, Dunbar & Condra). Ventral view of fragmental specimen showing some surface details and a number of borings, X1; Putnam Hill unit, loc. HOh-1; OSU 28902.

3, 5, 6. *Mahoningoceras pottsvillense* (Morningstar). Dorsal-end (**3**), cross-sectional (**5**), and lateral (**6**) views of exfoliated and incomplete holotype showing details of whorl sections, septa, sutures, and siphuncle, X1; Lower Mercer unit, loc. Lh-1; OSU 8995.

4. *Latitemnocheilus*? sp. #2. A mere fragment showing ventrolateral nodes, X1; Lower Mercer unit, loc. LIho-1; OSU 29313.

7. *Temnocheilus annulonodosus* Sturgeon, Windle, Mapes & Hoare. Ventral view of incomplete paratype showing external features and an epifauna of several specimens of *Crania modesta* White & St. John, X1; Columbiana unit, loc. Cuc-4; OSU 19547.



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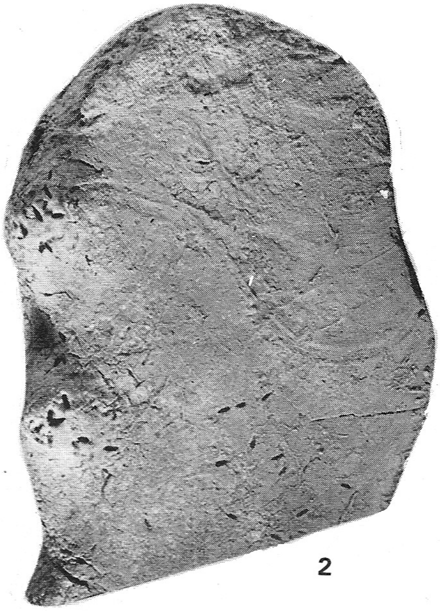

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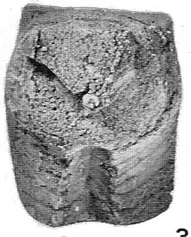

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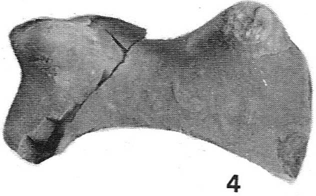

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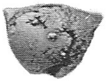

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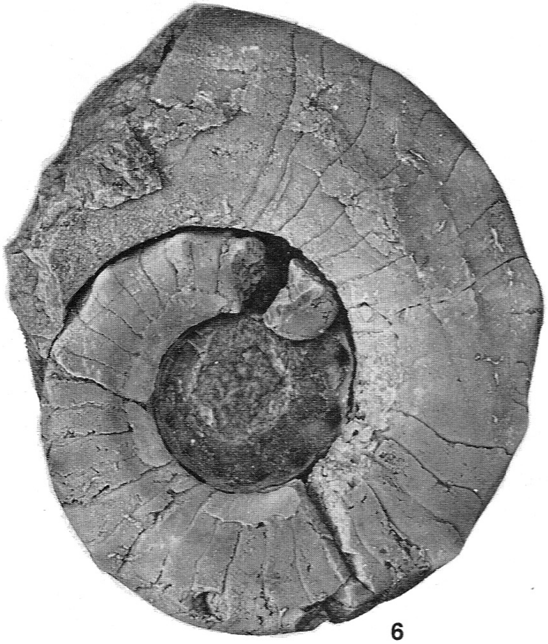

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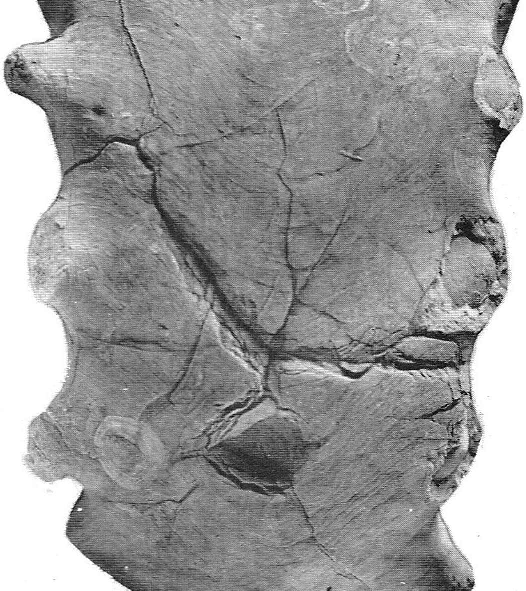

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PLATE 1–21

PLATE 1-22.—*Ungeroceras ungeri* Sturgeon & Miller

FIGURES 1-6. All from Putnam Hill unit.

1. Lateral view of large incomplete hypotype showing conchal curvature and some details of septa and sutures, X$^1/_2$; loc. Sc-5; OSU 28920.
2. Lateral view of incomplete holotype showing some details of surface ornament and of septa and siphuncle, X2; loc. Mg-3; OSU 19602.

3-5. Lateral views of three fragmental hypotypes showing details of surface ornament and of ventral sutures (**3**), X1; loc. Vel-15; OSU 28876 (**4**), 28877 (**3**), 28878 (**5**).

6. Lateral view of long incomplete hypotype showing conchal curvature, X$^2/_3$; loc. Ms-3; OSU 28874.

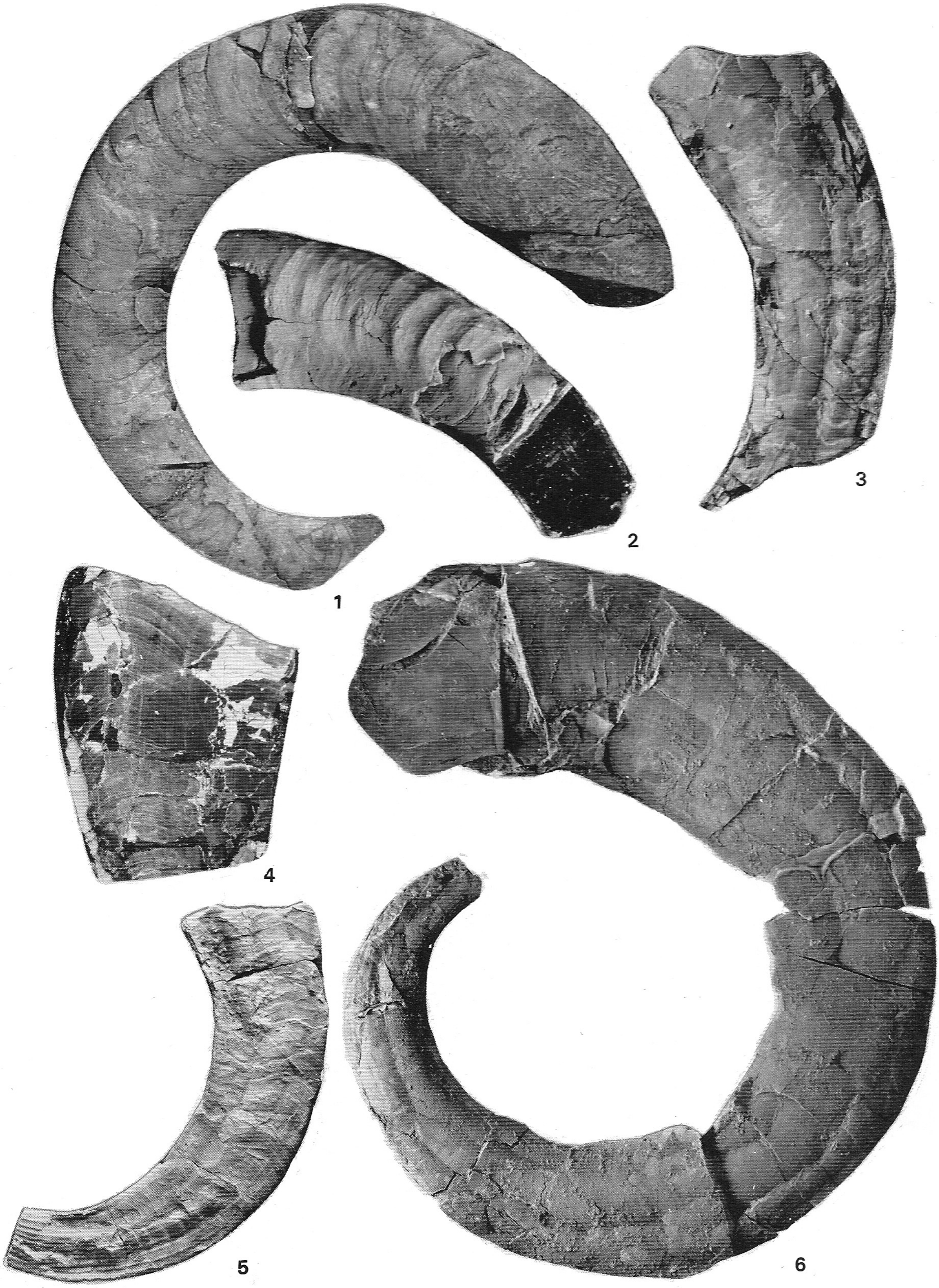


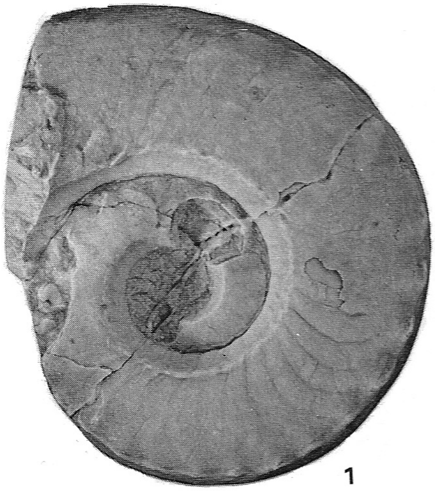
PLATE 1–22

PLATE 1-23.—*Domatoceras*

FIGURES 1-5. *Domatoceras obsoletum* Sturgeon. Columbiana unit.

- 1, 4. Lateral (**1**) and ventral (**4**) views of nearly complete holotype, X1; loc. Mg-10; OSU 18726.
- 2. Polished lateral-sectional view of nearly complete topotype showing septa, siphuncle, and umbilical perforation, X2; loc. Cp-3; OSU 19542.
- 3. Polished cross-sectional view of an incomplete paratype, X1; loc. Mg-2; OSU 18727.
- 5. Polished lateral-sectional view of an incomplete paratype showing septa, siphuncle, and umbilical perforation, X2; loc. Mg-2; OSU 18727.

6, 7. *Domatoceras oreskovichi* Sturgeon, Windle, Mapes & Hoare. Lateral (**6**) and dorsal-end (**7**) views of incomplete holotype, X1;Putnam Hill unit, loc. Ms-3; OSU 29138.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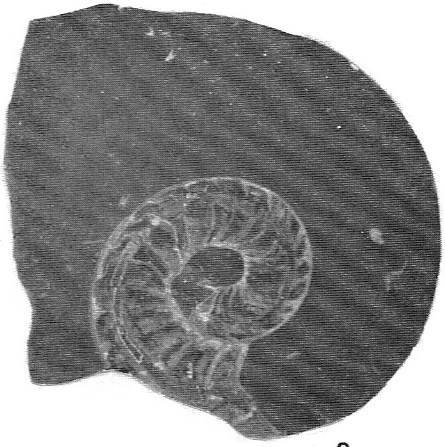
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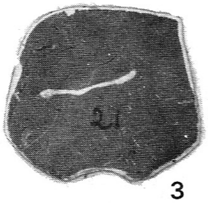

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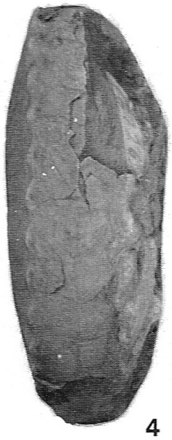
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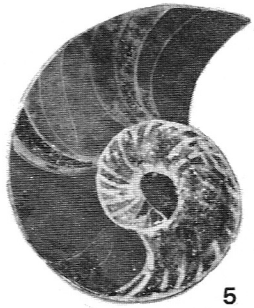
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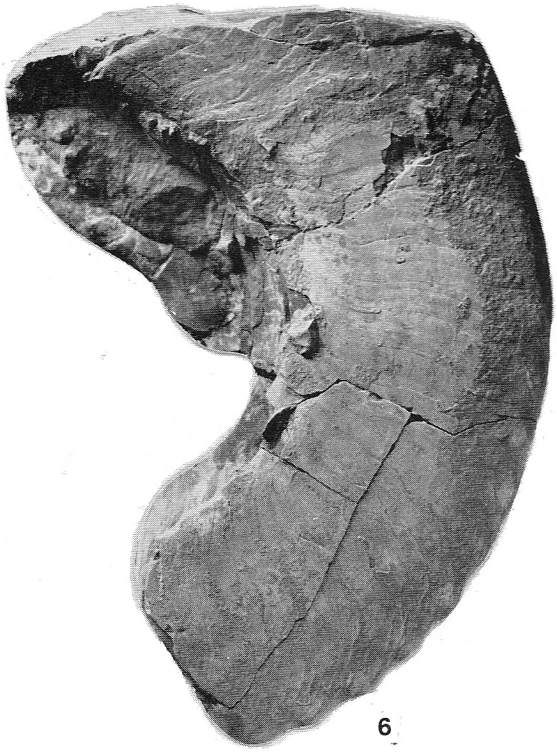
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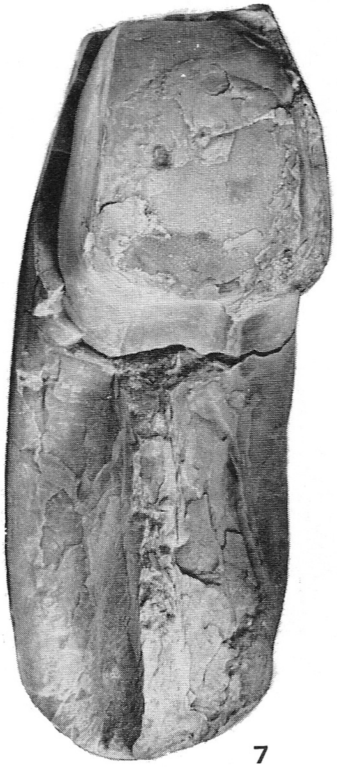
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PLATE 1–23

PLATE 1-24.—*Domatoceras*

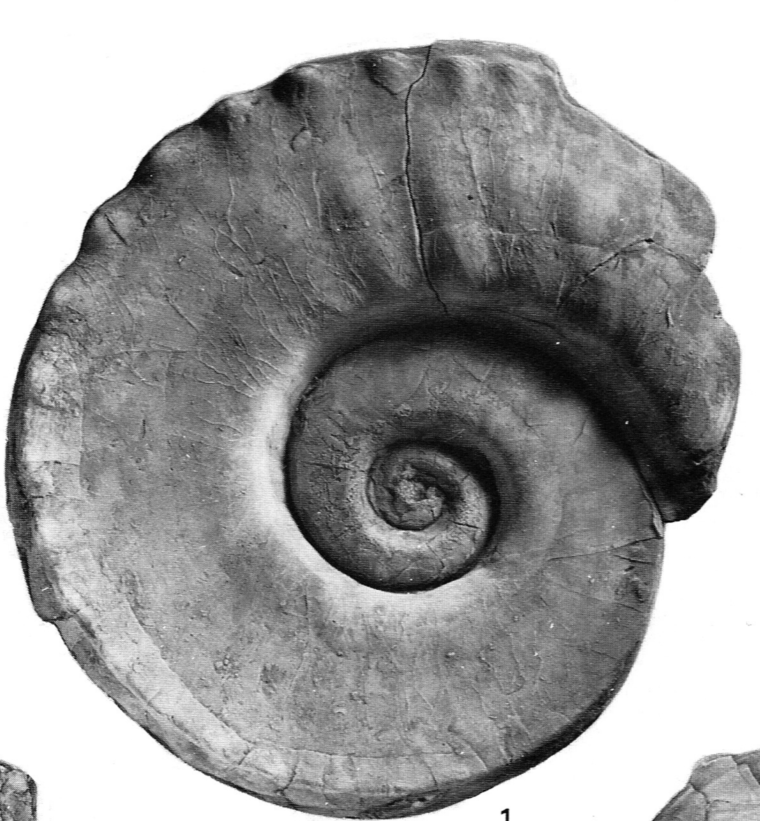
FIGURE 1. *Domatoceras williamsi* Miller & Owen. Lateral view of lectotype showing coiling, umbilicus, ventrolateral nodes, and transverse lateral ridges, X1; Cherokee Formation, loc. MO:Hw-1; SUI 13418.

2, 3. *Domatoceras oreskovichi* Sturgeon, Windle, Mapes & Hoare. Lateral views of two doubtful fragmental specimens, X1; Putnam Hill unit, loc. Mg-4; OSU 18729.

4-8. *Domatoceras* spp. All X1 (approx.)

4, 5. Cross-sectional views of two fragmental specimens; Ames unit, loc. MUu-2; OSU 29159.

6-8. Ventral (**6**), lateral (**7**), and dorsal-end (**8**) views of incomplete specimen; Brush Creek unit, loc. Cma-9; OSU 29158.



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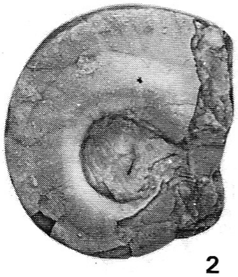

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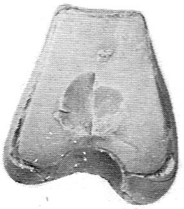

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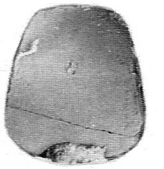

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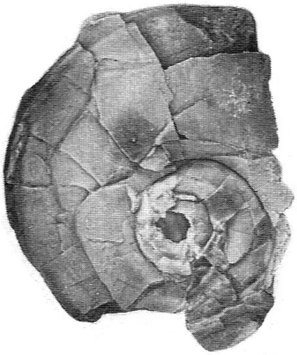

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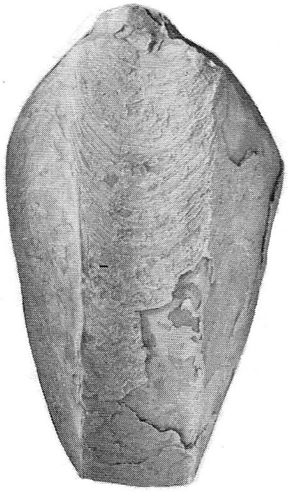

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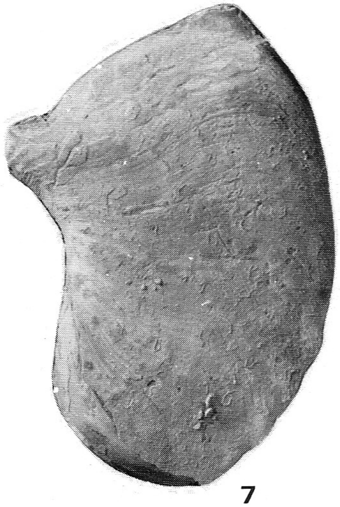

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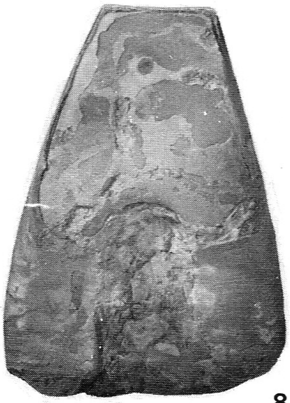

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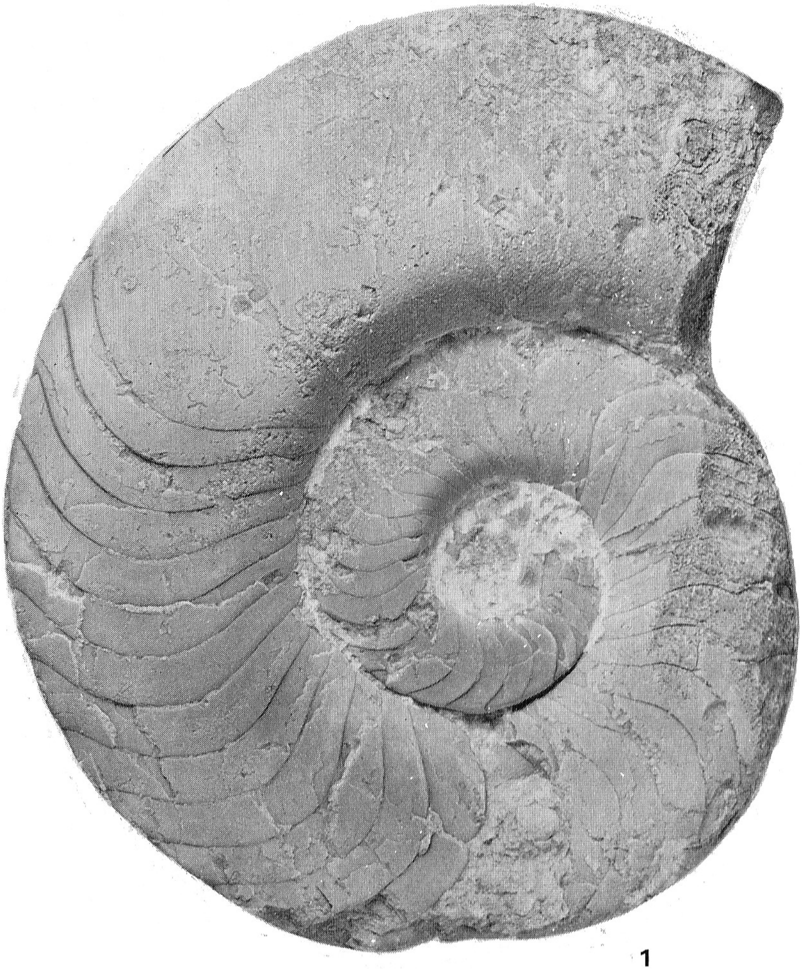
PLATE 1–24

PLATE 1-25.—*Domatoceras williamsi* Miller & Owen

FIGURE 1. Lateral view of nearly complete exfoliated hypotype showing phragmocone and much of body chamber, X1; Vanport unit, loc. Jmi-3; OSU 19681.

2. Lateral view of nearly complete internal mold of hypotype showing phragmocone, much of body chamber, and umbilical perforation X1; Lower Mercer unit?, loc. CScl-1; OSU 19601.



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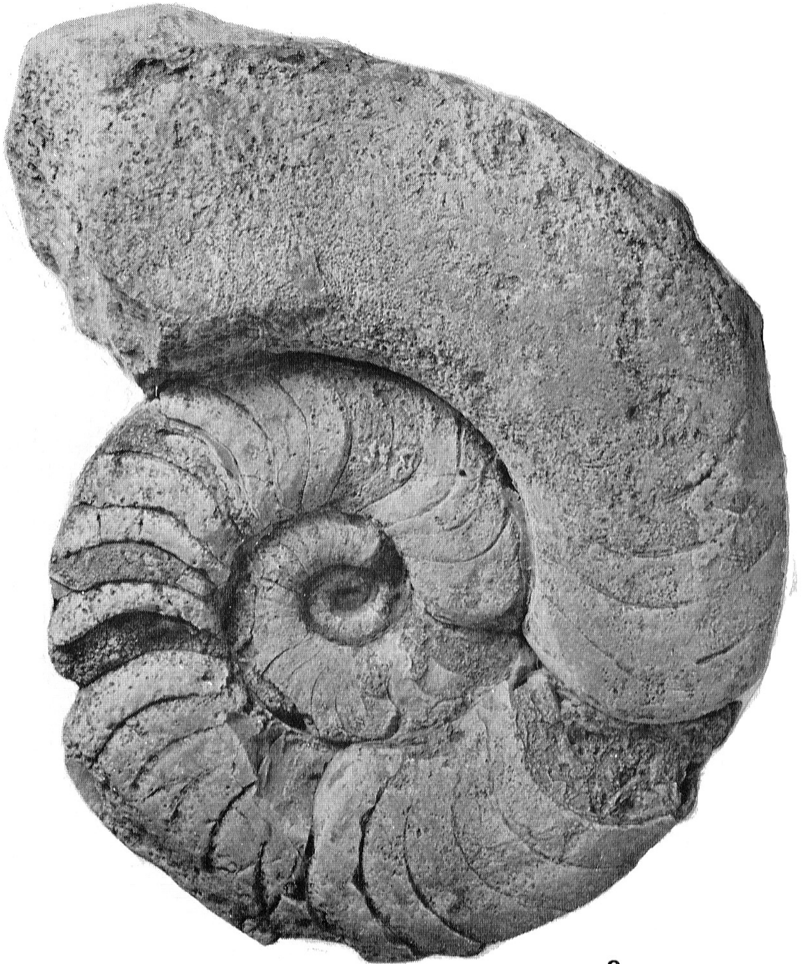

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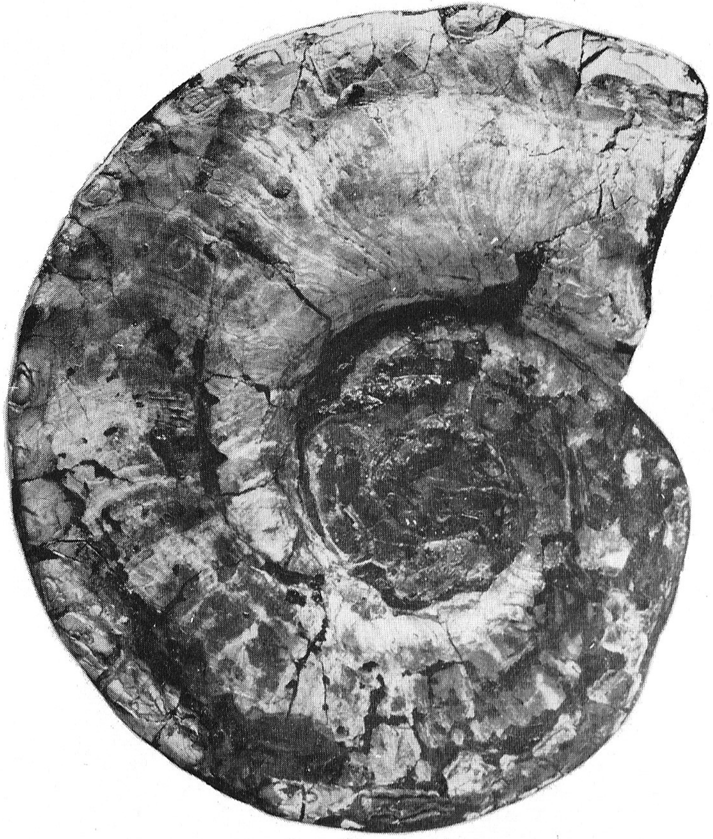
PLATE 1–25

PLATE 1-26.—*Domatoceras oreskovichi* Sturgeon, Windle, Mapes & Hoare

FIGURE 1. Lateral view of nearly complete distorted paratype, X1; Putnam Hill unit, loc. Td-4; OSU 29140.

2. Lateral view of nearly complete, somewhat mashed paratype, X$^{3}/_{4}$; Putnam Hill unit, loc. Ty-3; OSU 29141.



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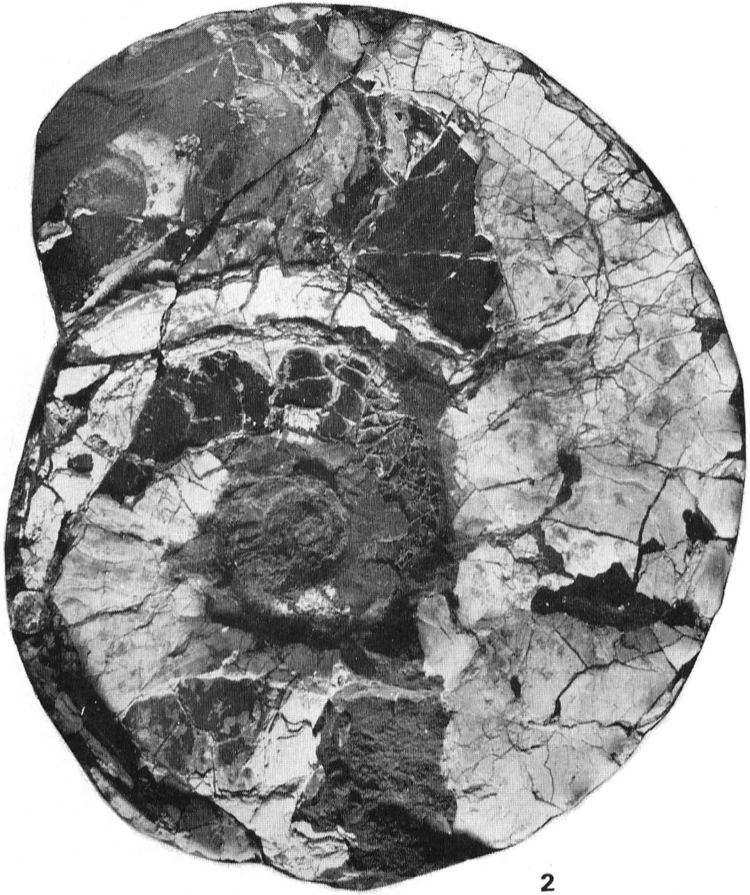

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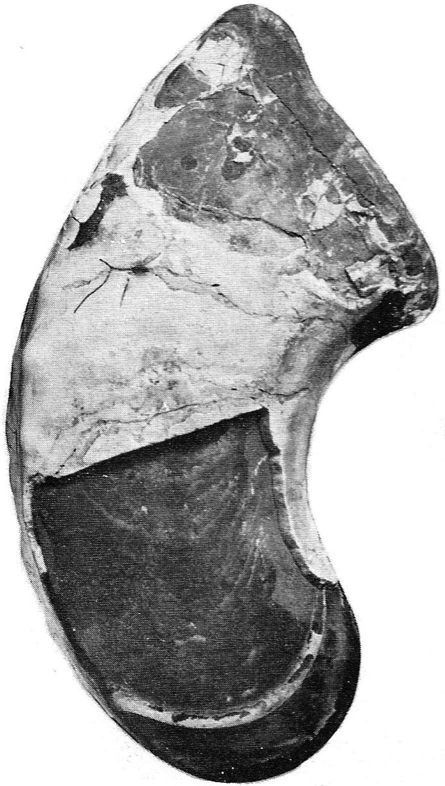
PLATE 1–26

PLATE 1-27.—*Domatoceras oreskovichi* Sturgeon, Windle, Mapes & Hoare

FIGURES 1-3. Lateral (**1**, **3**) and ventral (**2**) views of incomplete paratype, X1; Putnam Hill unit, loc. Ms-3; OSU 29139.

4-6. Ventral (**4**), dorsal-end (**5**), and lateral (**6**) views of incomplete doubtful paratype, X1; Washingtonville unit, loc. CAr-2; OSU 29156.



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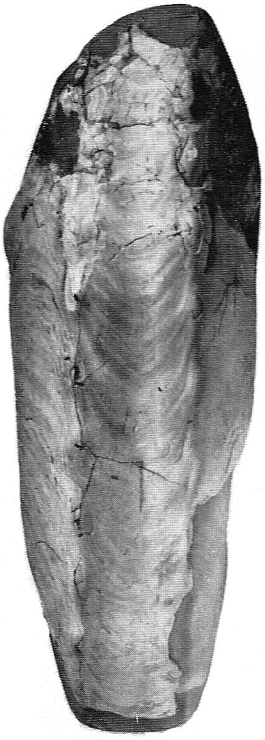

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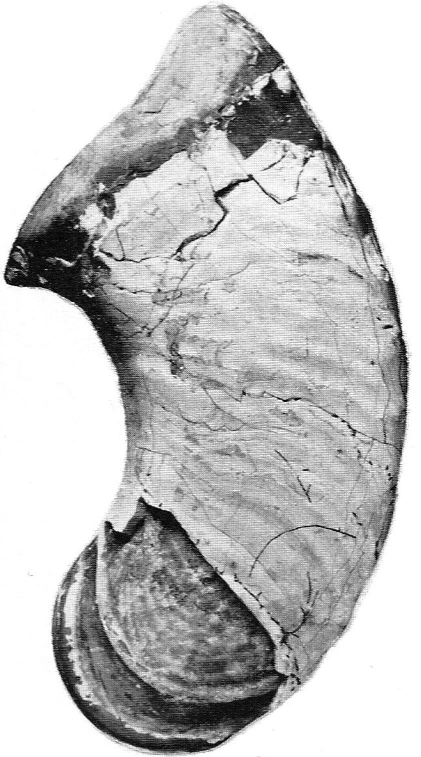

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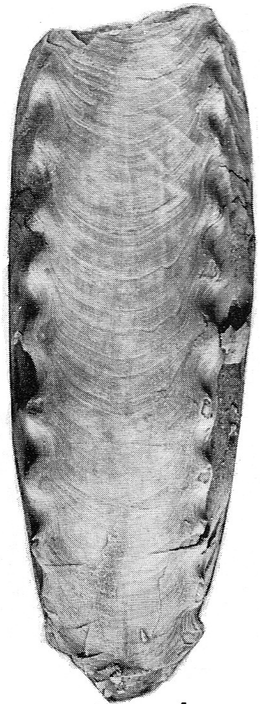

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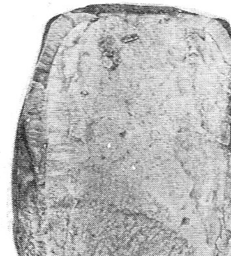

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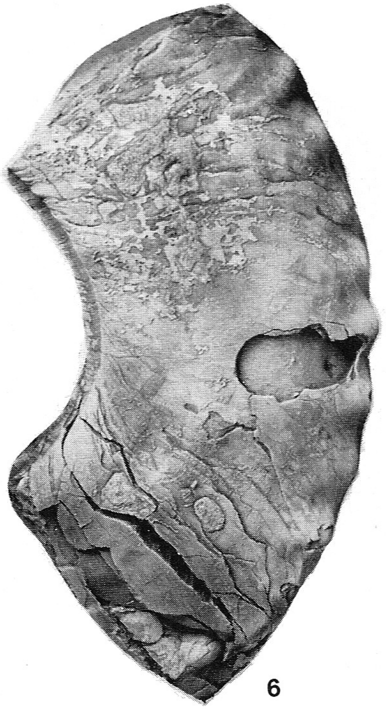

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PLATE 1–27

PLATE 1-28.—*Domatoceras*

FIGURES 1-4. *Domatoceras* cf. *D. highlandense* (Worthen). All X1.

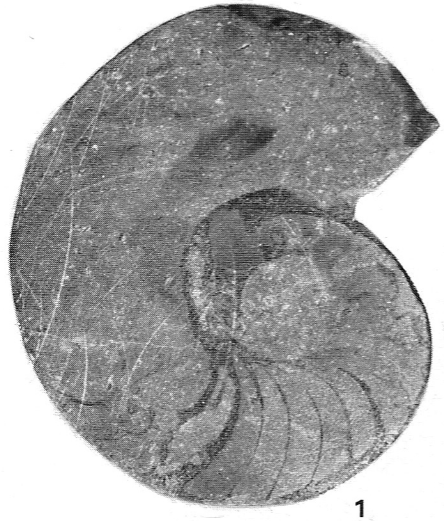
1. Polished lateral section showing septa and umbilical perforation of nearly complete specimen; Ames unit, loc. Aa-58; OSU 29154.
2. Lateral view of incomplete specimen; Cambridge unit, loc. Gwe-1; OSU 29151.

3, 4. Lateral (**3**) and ventral (**4**) views of exfoliated specimen; Ames unit, loc. JEuc-1; OSU 29152.

5-7. *Domatoceras shepherdi* Sturgeon. All X1; Washingtonville unit, loc. CAr-2.

5, 7. End (**5**) and ventrolateral (**7**) views of incomplete hypotype showing several attached *Crania modesta* White & St. John; OSU 28901B.

6. End view of small fragmental hypotype; OSU 28901A.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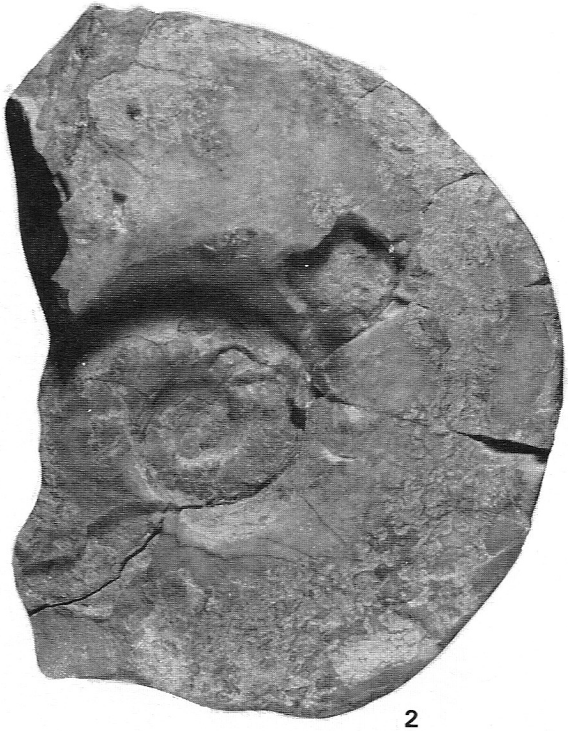
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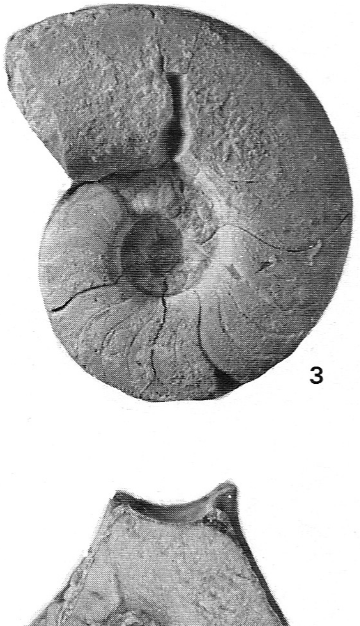
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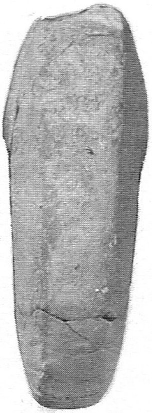
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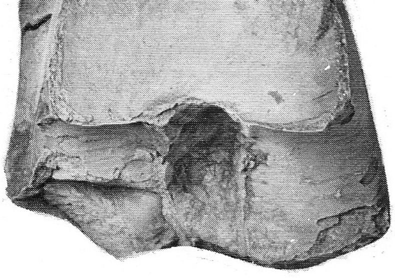
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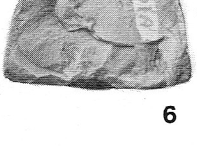
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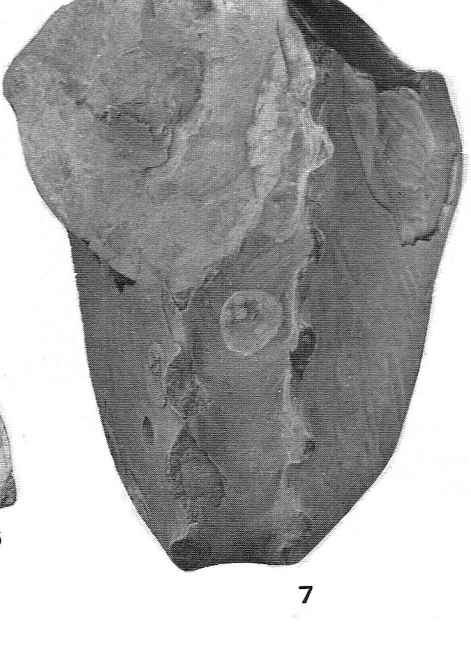
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PLATE 1–28

PLATE 1-29.—*Domatoceras shepherdi* Sturgeon

FIGURE 1. Lateral view of incomplete holotype, X1; Columbiana unit, loc. Mg-10; OSU 18728.

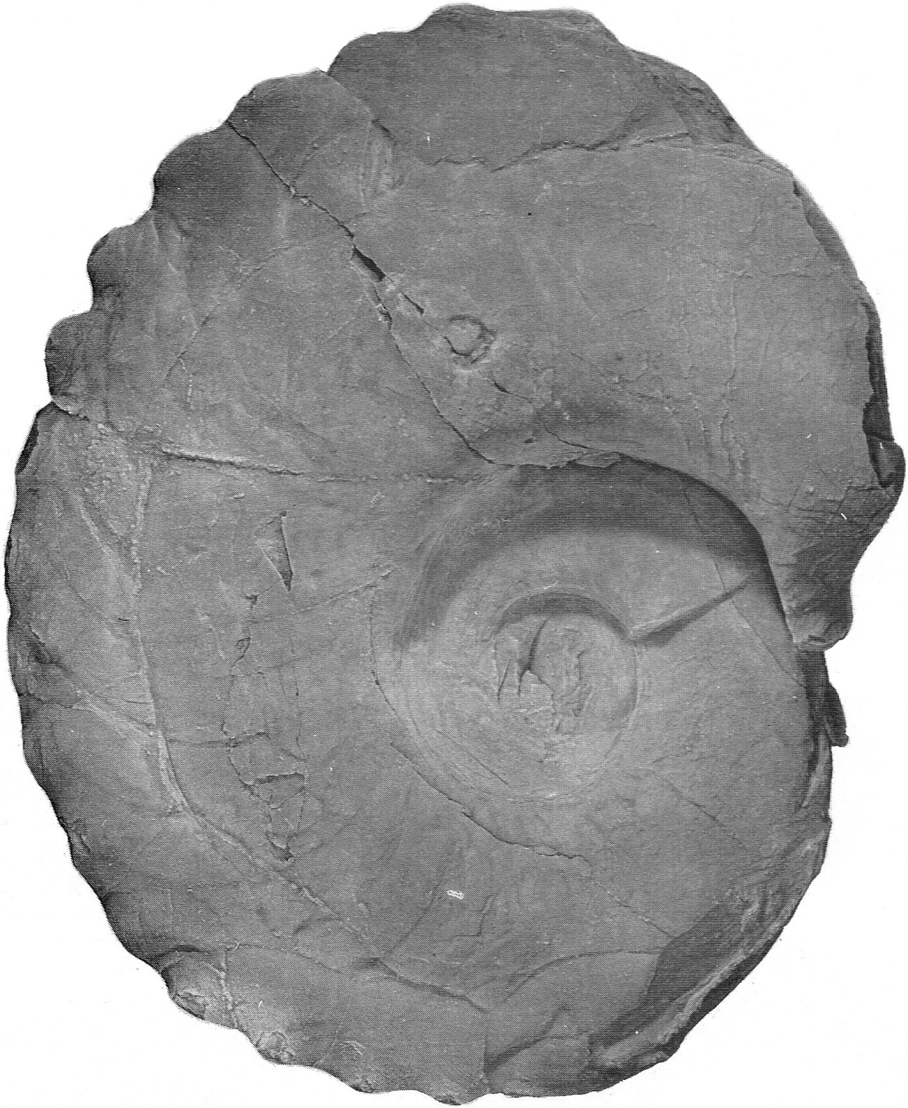

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PLATE 1–29

PLATE 1-30.—*Stenodomatoceras gardi* (Murphy)

FIGURES 1-8. All X1; Brush Creek unit, loc. Cma-3.

1, 7. Lateral (**1**) and ventral (**7**) views of incomplete topotype; OSU 28947.

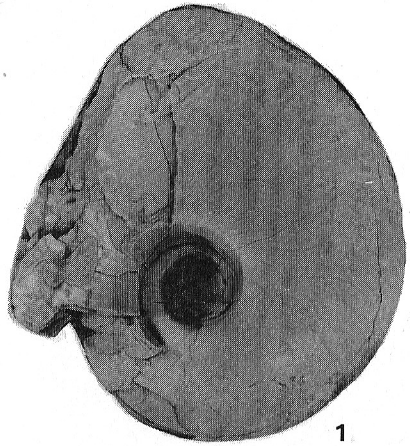
2. Polished lateral view of topotype showing traces of septa and siphuncle and conglomeratic filling of body chamber; OSU 28962.

3. Lateral view of small topotype showing umbilical perforation; OSU 28949.

4, 5. Ventral (**4**) and lateral (**5**) views of incomplete topotype; OSU 28967.

6. Polished cross-sectional view of topotype; OSU 28961.

8. Lateral view of largely exfoliated incomplete topotype; OSU 28945.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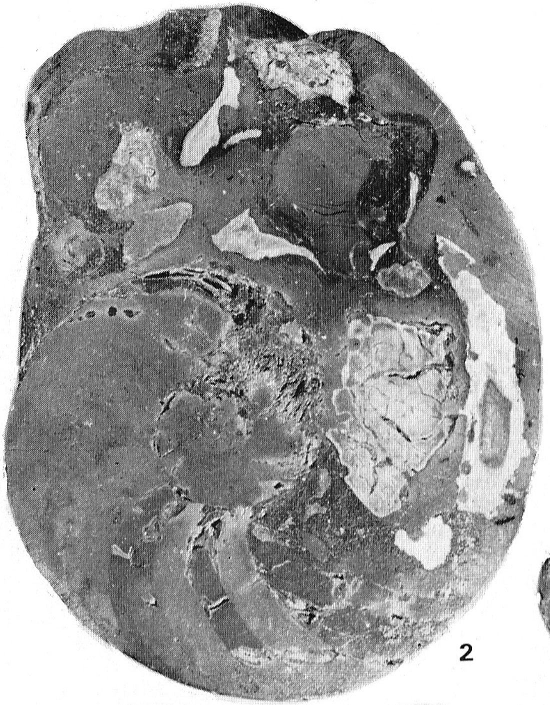
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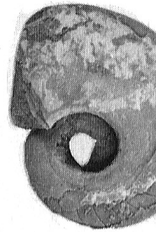
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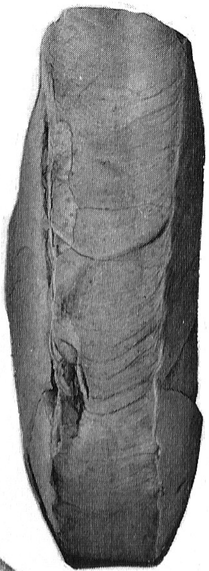
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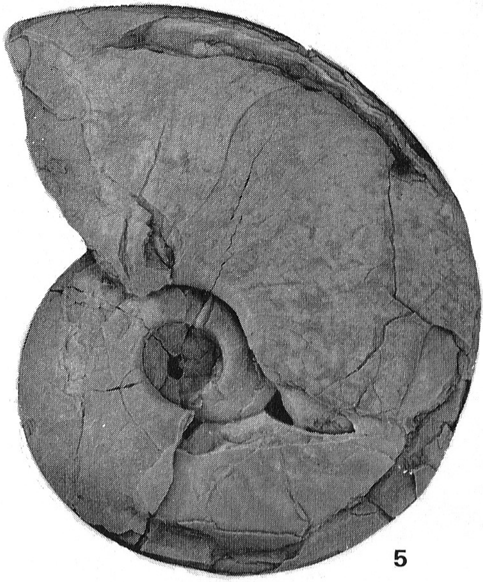
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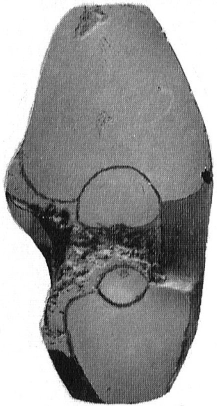
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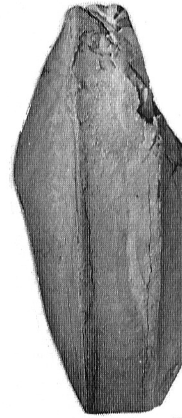
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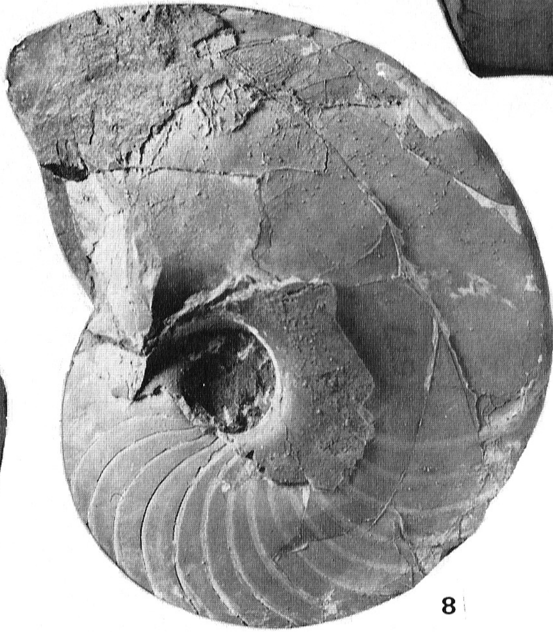
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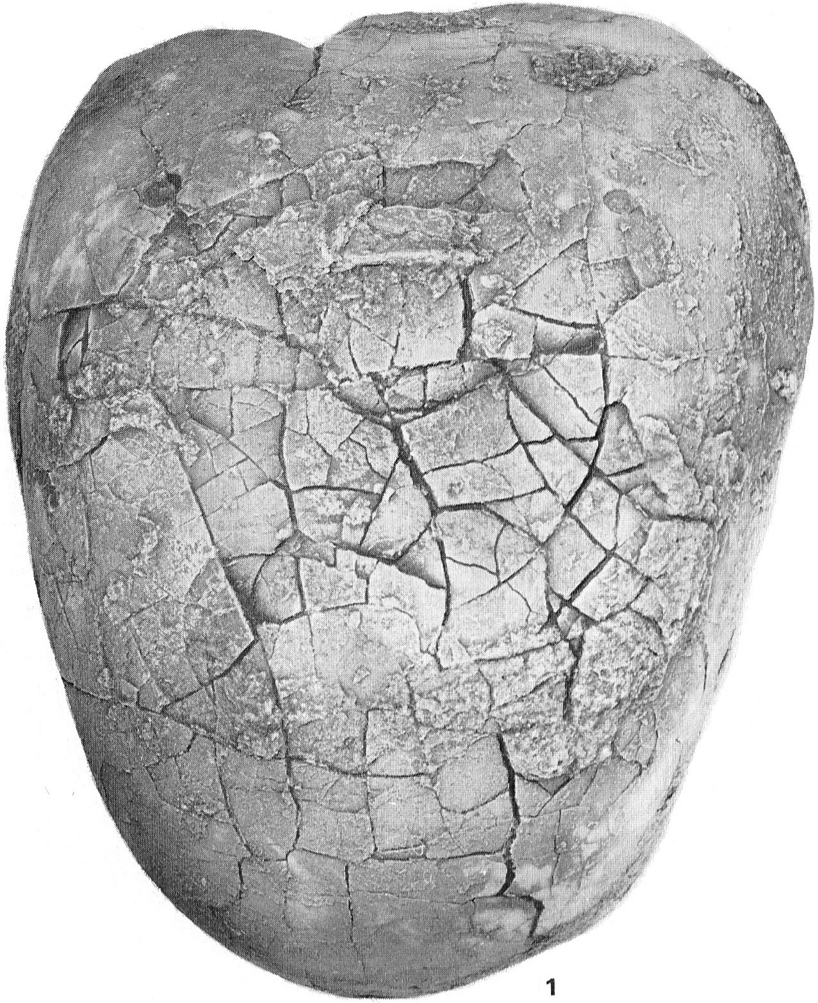
PLATE 1–30

PLATE 1-31.—*Solenochilus greenensis* Sturgeon

FIGURE 1. Ventral view of incomplete fractured hypotype, X1; Columbiana unit, loc. Tw-1; OSU 29265.

2. Lateral view of incomplete hypotype showing surface ornament and umbilical carina, X1; Columbiana unit, loc. Twa-1; OSU 28842.



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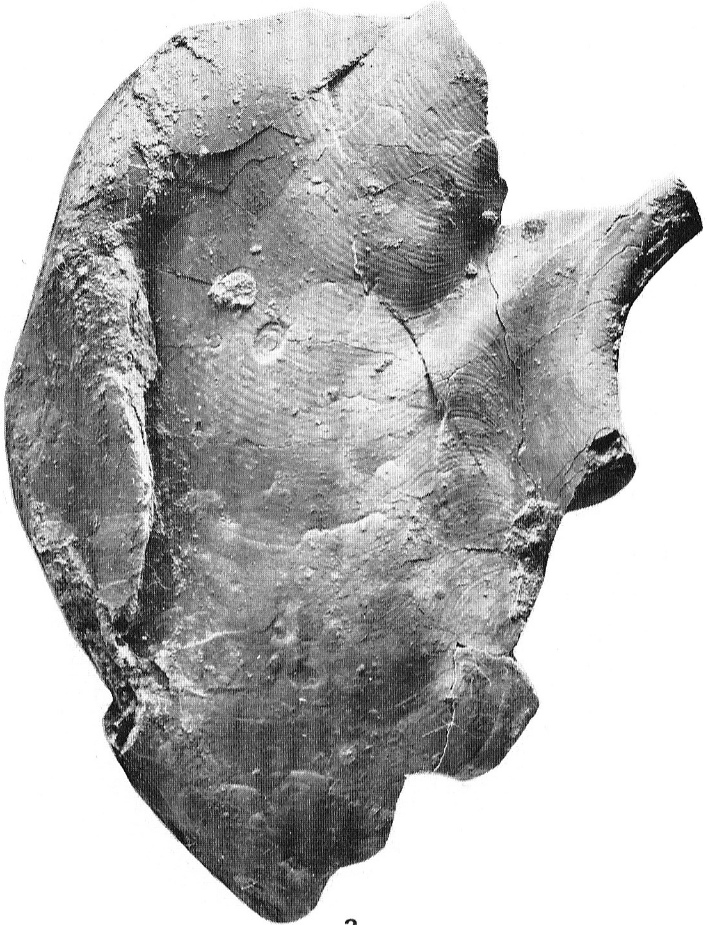

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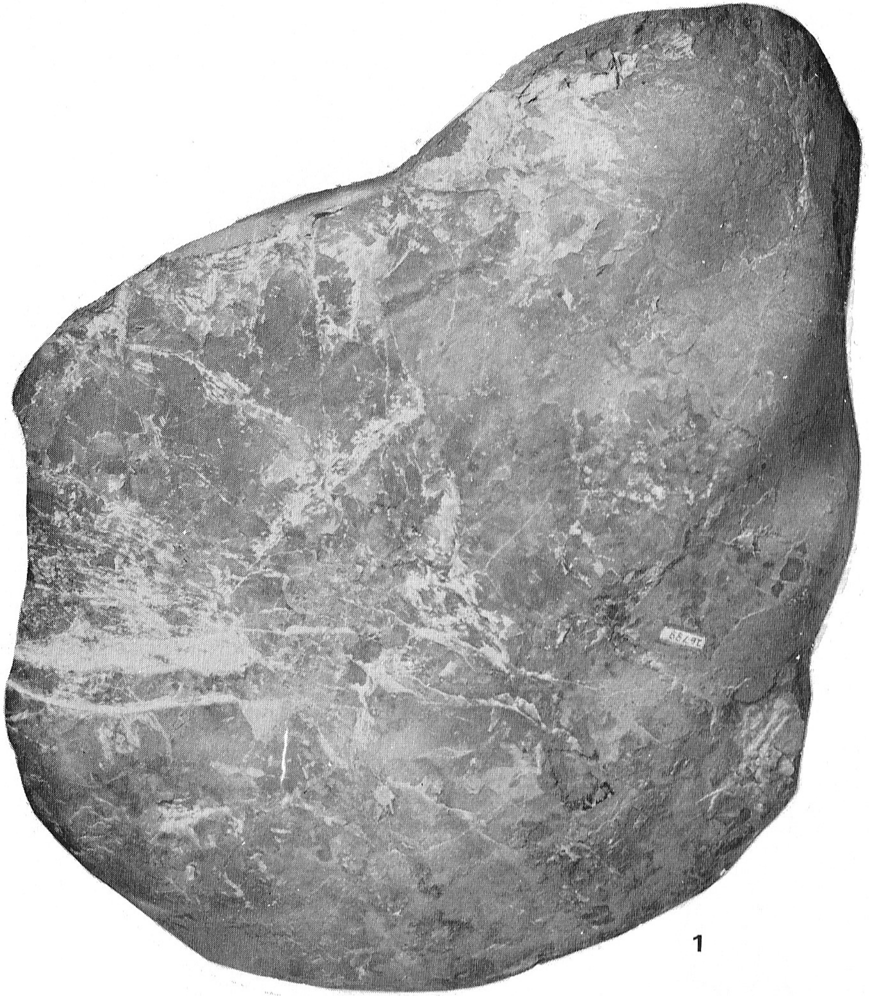
PLATE 1–31

PLATE 1-32.—*Solenochilus*

FIGURE 1. *Solenochilus cambridgensis* Frontz. Ventral view of exfoliated incomplete holotype showing ventrolateral oblique corrugations, X$\frac{1}{2}$; Cambridge unit, loc. Gwe-1; OSU 26788.

2. *Solenochilus greenensis* Sturgeon. Lateral view of internal mold of incomplete hypotype possibly showing base of broken and healed lateral spine, X1; Columbiana unit, loc. Cuc-1; OSU 19553.



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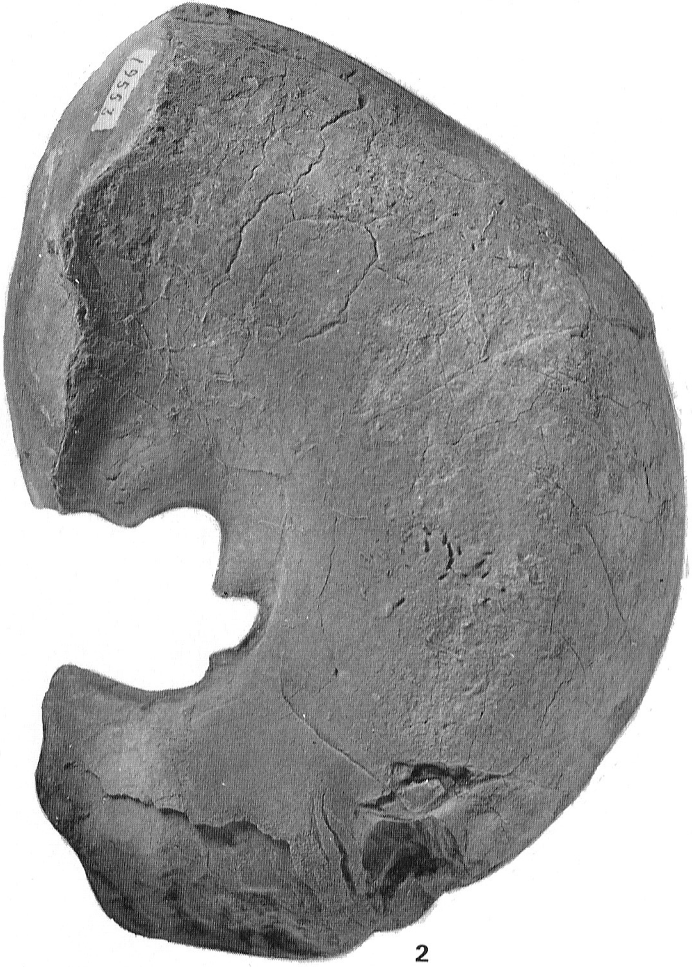

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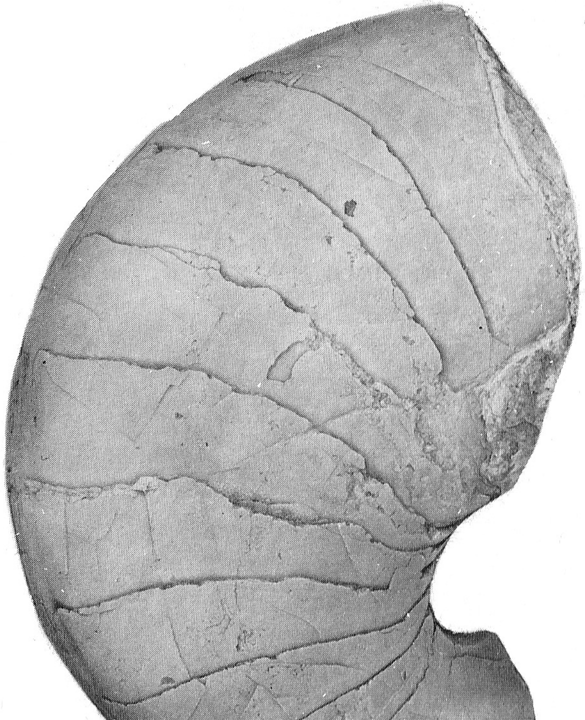
PLATE 1–32

PLATE 1-33.—*Solenochilus*

FIGURES 1, 2. *Solenochilus bognari* Sturgeon. Lateral (**1**) and ventral (**2**) views of exfoliated incomplete holotype showing some details of sutures, X$^{3}/_{4}$ (approx.); Vanport unit, loc. Tl-1; OSU 18730.

3. *Solenochilus greenensis* Sturgeon. Ventral view of exfoliated incomplete hypotype showing some details of sutures and siphuncle, X1; Columbiana unit?, loc. Tg-2; CWR 5358.

4. *Solenochilus cambridgensis* Frontz. Cross-sectional view of two oldest whorls of paratype, X$^{2}/_{3}$ (approx.); Cambridge unit, loc. Gwe-1; OSU 26790.



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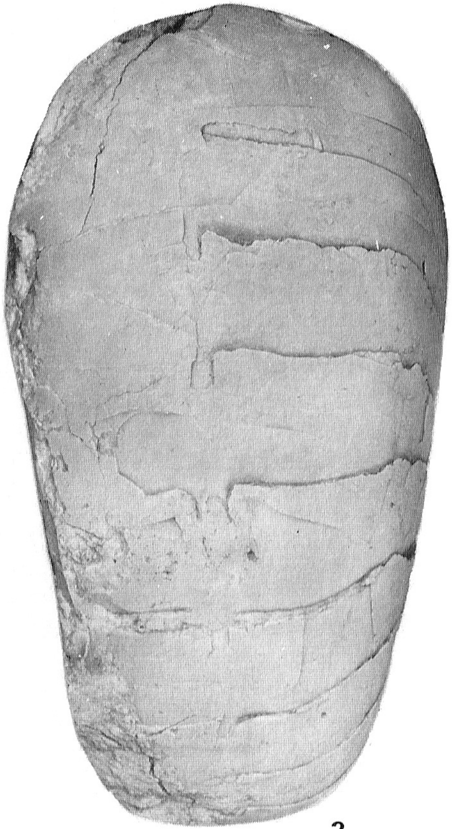

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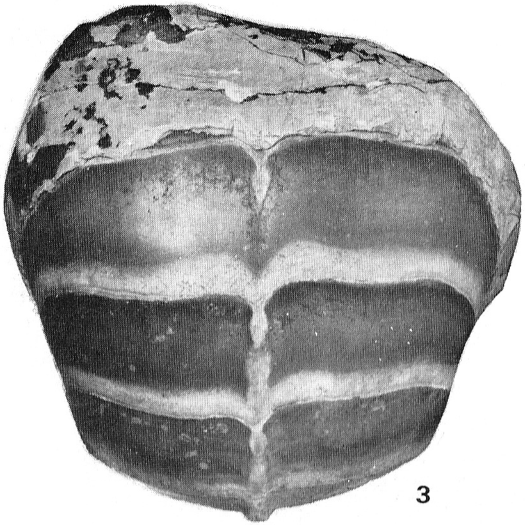

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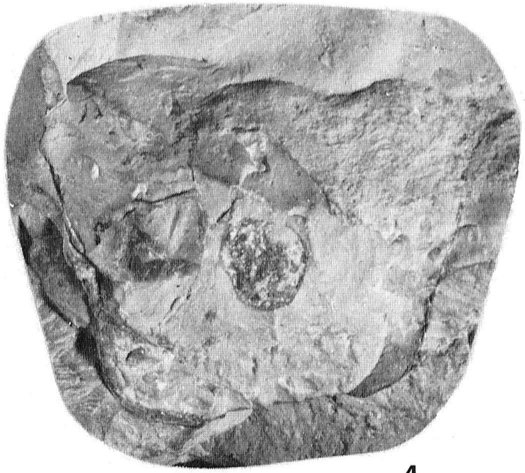

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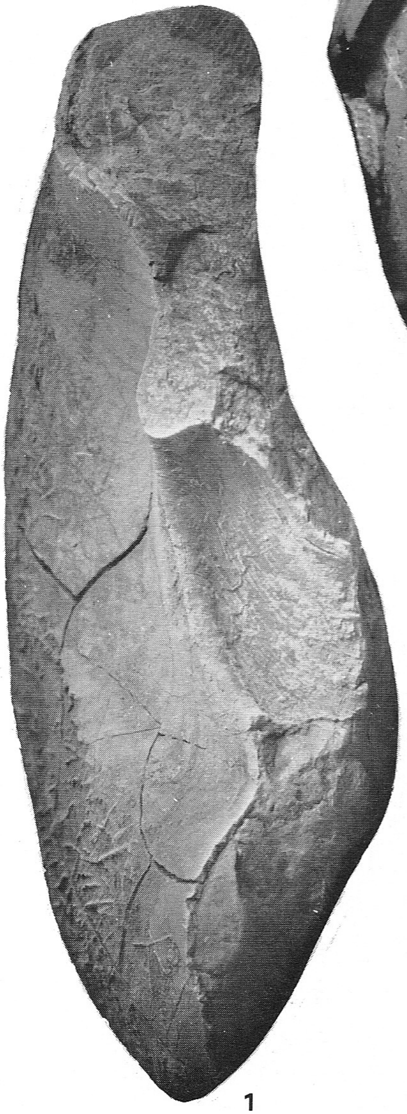
PLATE 1–33

PLATE 1-34.—*Solenochilus greenensis* Sturgeon

FIGURE 1. Dorsolateral view of incomplete hypotype showing umbilical shoulder and carina, X2; Columbiana unit, loc. Ss-5; OSU 28843.

2. Ventral view of incomplete exfoliated hypotype showing outline of ventromyarian muscle attachment, X1; Columbiana unit, loc. Mg-2; OSU 19550.

3. Partially polished ventral view of incomplete syntype showing some details of siphuncle, X1; Columbiana unit, loc. Mg-7; OSU 18731.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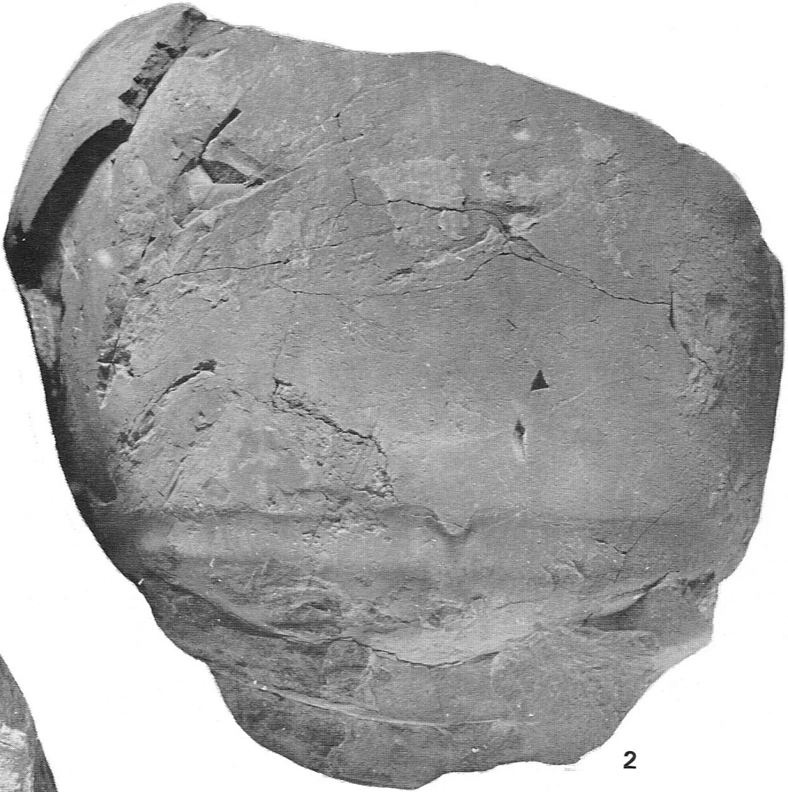
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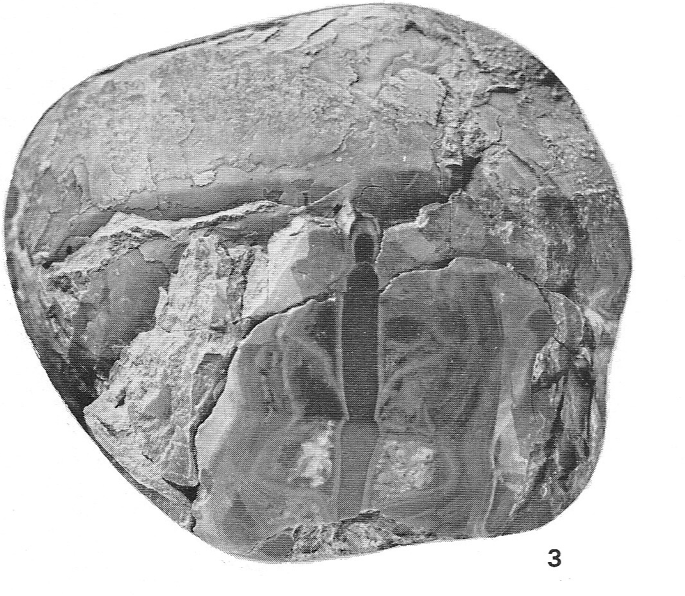
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PLATE 1–34

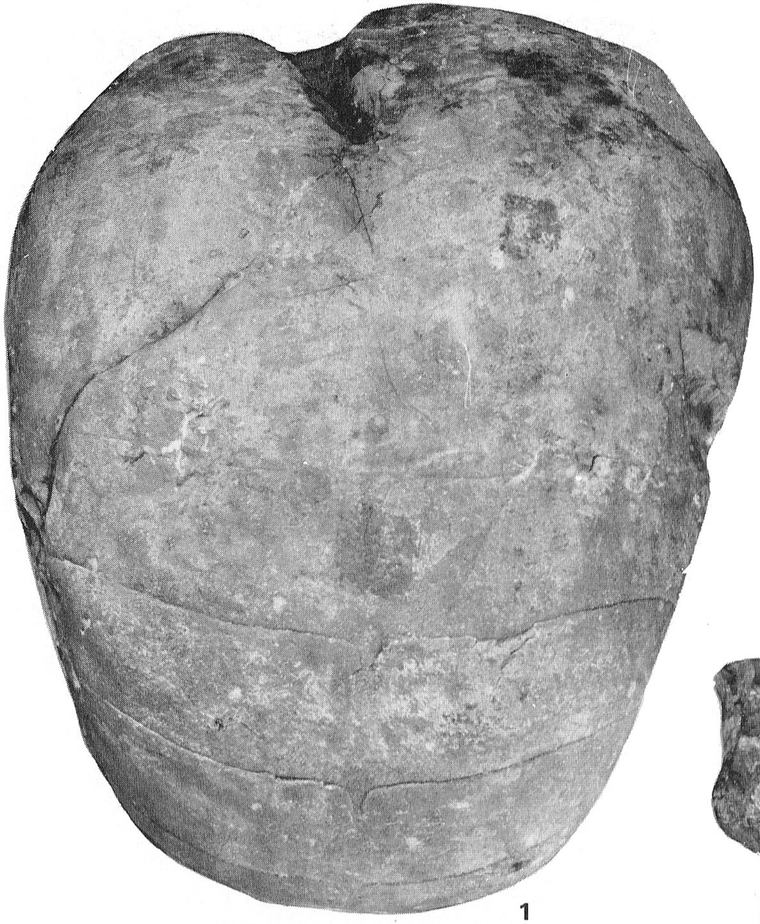
PLATE 1-35.—*Solenochilus*

FIGURES 1, 3. *Solenochilus johnstoni* Sturgeon, Windle, Mapes & Hoare. X$^1/_2$; Brush Creek unit, loc. Ale-33; OSU 28841.

1. Ventral view of exfoliated incomplete holotype showing parts of body chamber and phragmocone and some details of sutures and siphuncle.

3. Lateral view of holotype showing some details of coiling and of sutures.

2. *Solenochilus mcfarlandi* Sturgeon, Windle, Mapes & Hoare. Ventrolateral view of partially exfoliated incomplete paratype showing parts of body chamber, phragmocone, and some details of sutures and siphuncle, X1; Brush Creek unit, loc. Cma-3; OSU 28855.



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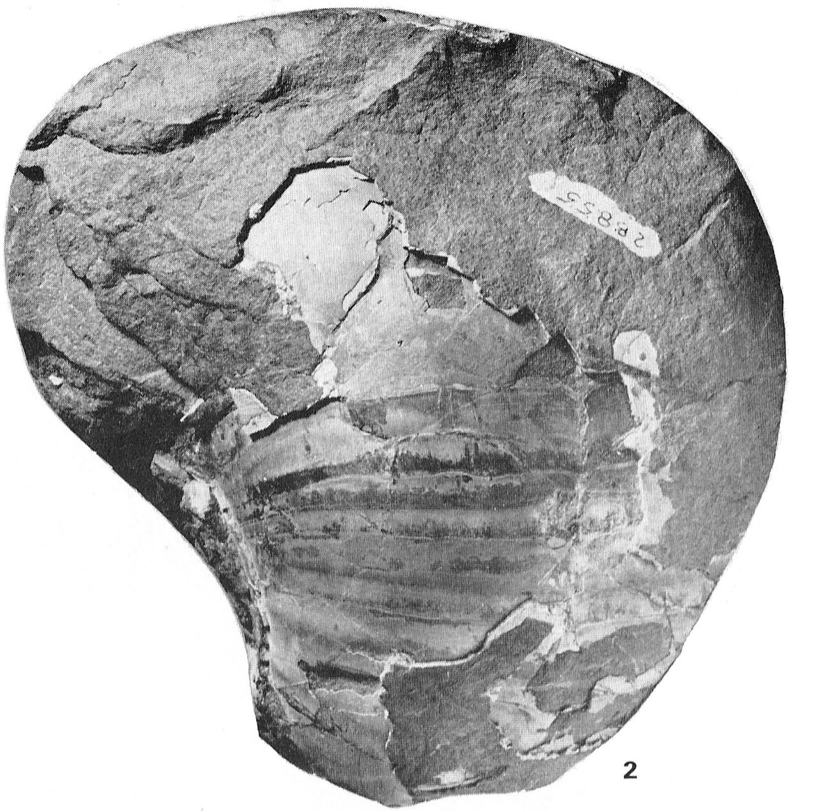

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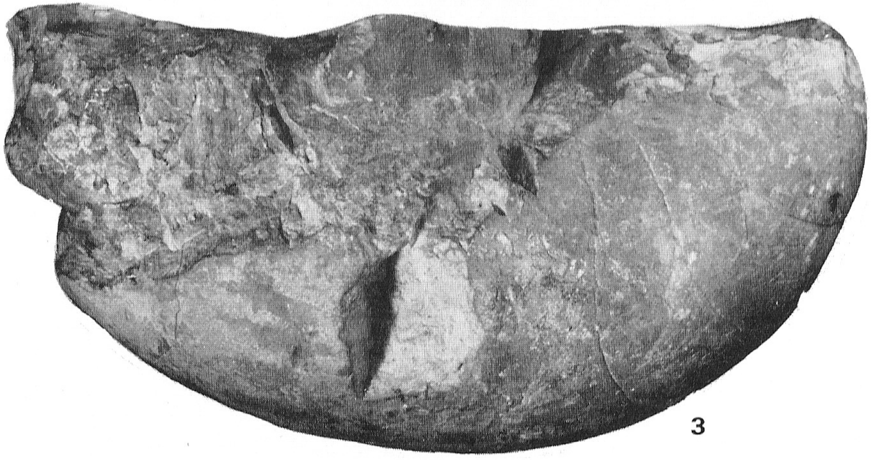

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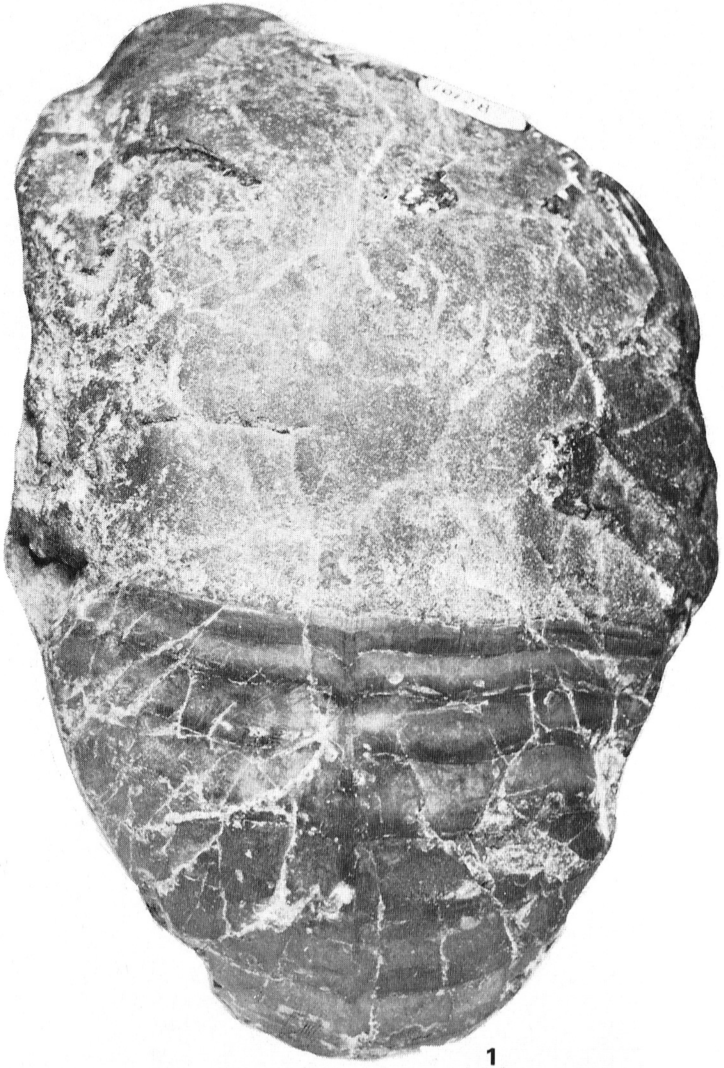
PLATE 1–35

PLATE 1-36.—*Solenochilus*

FIGURES 1, 2. *Solenochilus peculiare* Miller & Owen. X1; Lower Mercer unit.

1. Ventral view of exfoliated incomplete hypotype showing parts of body chamber and phragmocone, including some details of sutures and siphuncle; loc. Sc-2; OSU 10128.
2. Partial ventral view of partially exfoliated incomplete hypotype showing some details of sutures and siphuncle; loc. Hfg-5; OSU 28864.

3. *Solenochilus millhorni* Sturgeon, Windle, Mapes & Hoare. Partial ventral view of partially exfoliated incomplete paratype showing some details of sutures and siphuncle, X1; Putnam Hill-Vanport units undifferentiated, loc. Td-4; OSU 28845.



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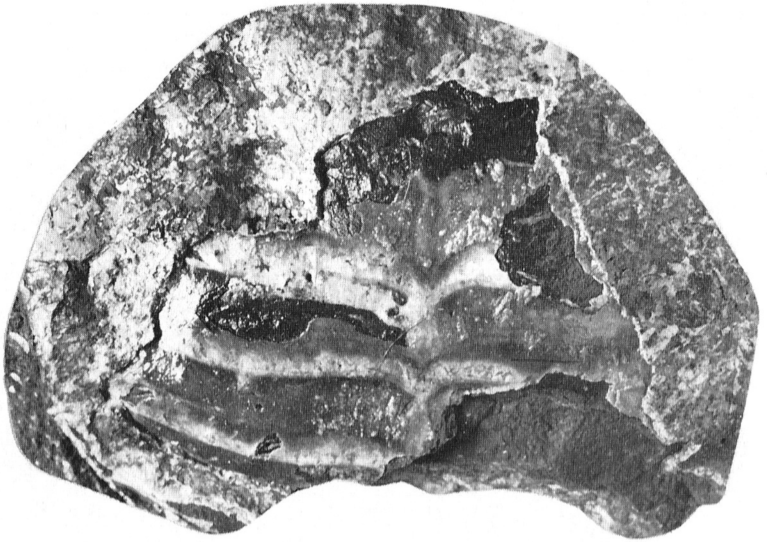

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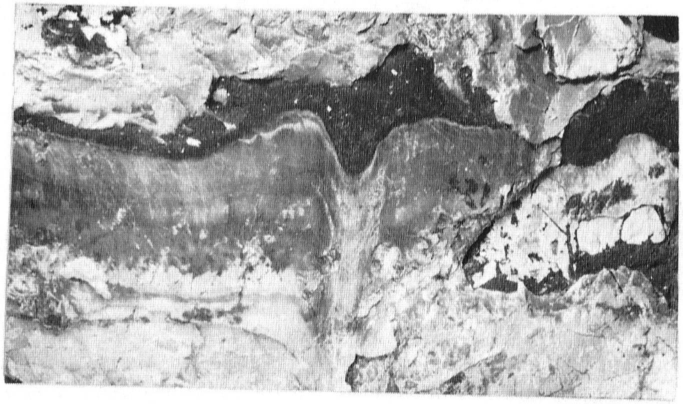

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PLATE 1–36

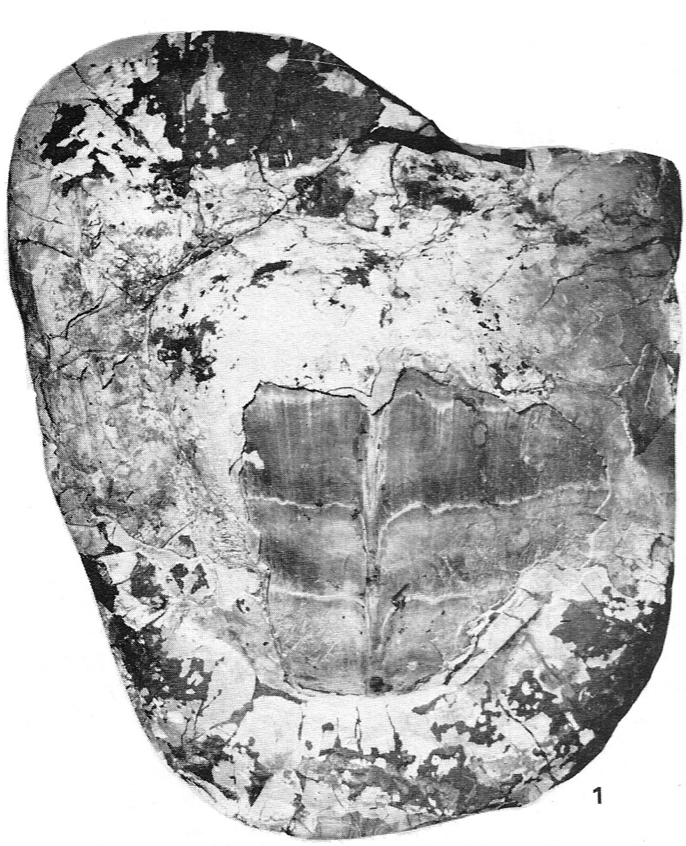
PLATE 1-37.—*Solenochilus*

FIGURES 1, 4. *Solenochilus millhorni* Sturgeon, Windle, Mapes & Hoare. Views of partially exfoliated incomplete holotype showing some details of sutures, siphuncle, and lines on exterior of internal mold of phragmocone; Putnam Hill-Vanport units undifferentiated, loc. Td-4; OSU 28844.

1. Ventral view, X½.
4. Close-up view of part of venter, X1.

2, 3. *Solenochilus mcfarlandi* Sturgeon, Windle, Mapes & Hoare. Views of partially exfoliated incomplete holotype showing parts of body chamber and phragmocone, X1; Brush Creek unit, loc. Cma-3; OSU 28854.

2. Lateral view showing some details of sutures.
3. Ventral view of holotype showing some details of sutures, siphuncle, and outline of ventromyarian muscle scar.



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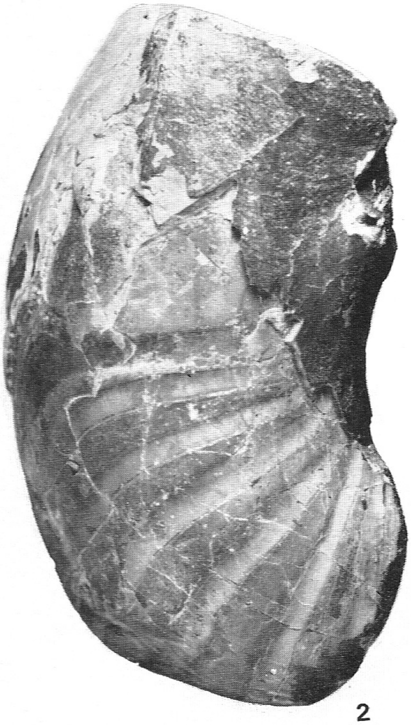

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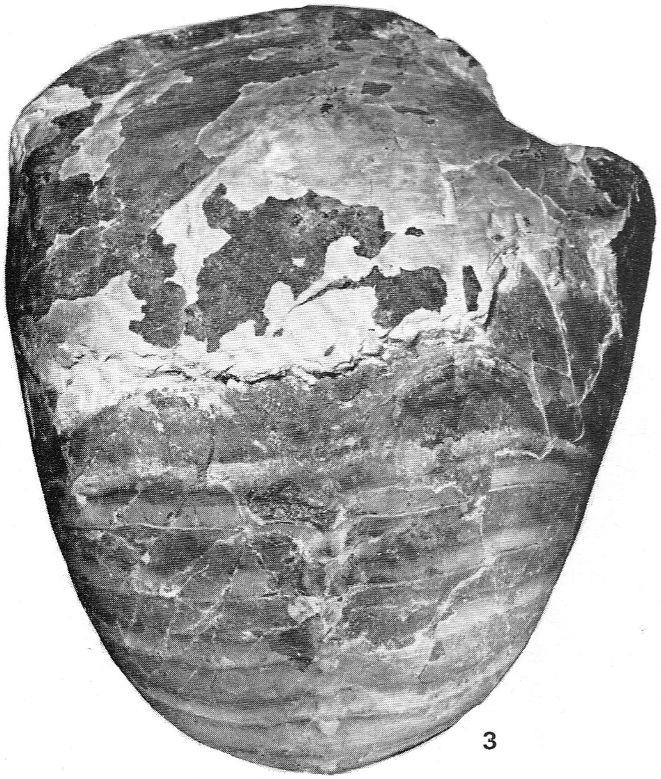

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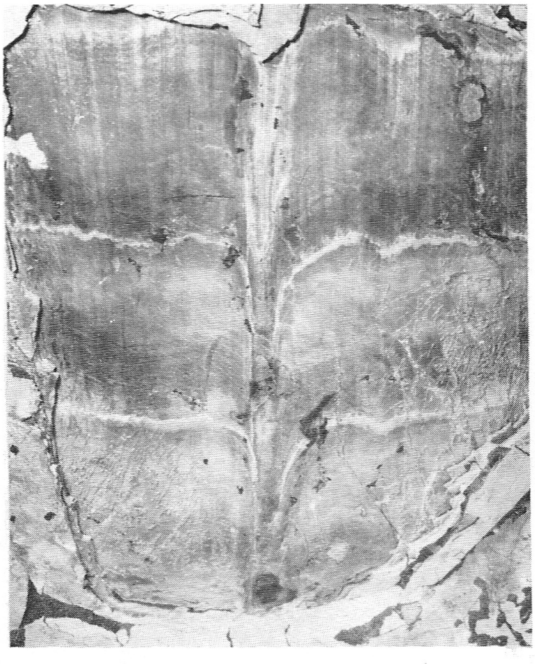

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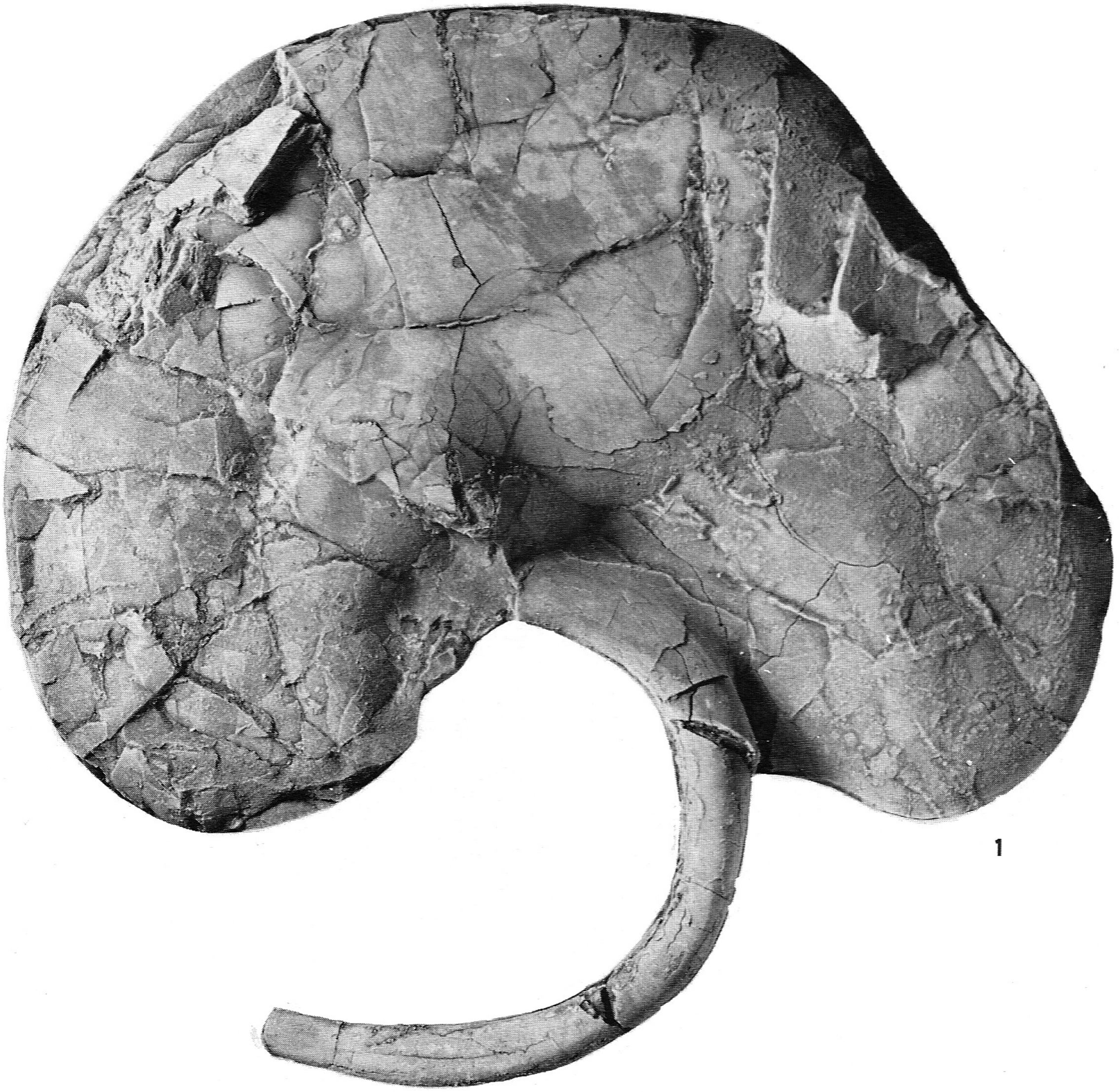
PLATE 1–37

PLATE 1-38.—*Solenochilus* cf. *S. springeri* (White & St. John)

FIGURES 1, 2. Views of mashed specimen; Putnam Hill unit, loc. Ms-3; OSU 28850.
1. Lateral view showing curved lateral spine, X1.
2. Enlarged view of small surface area showing ornament, X2.



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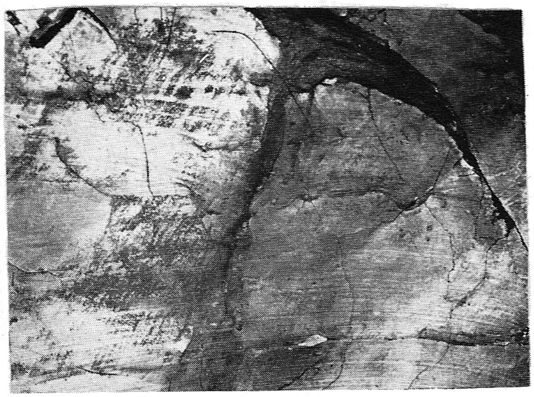

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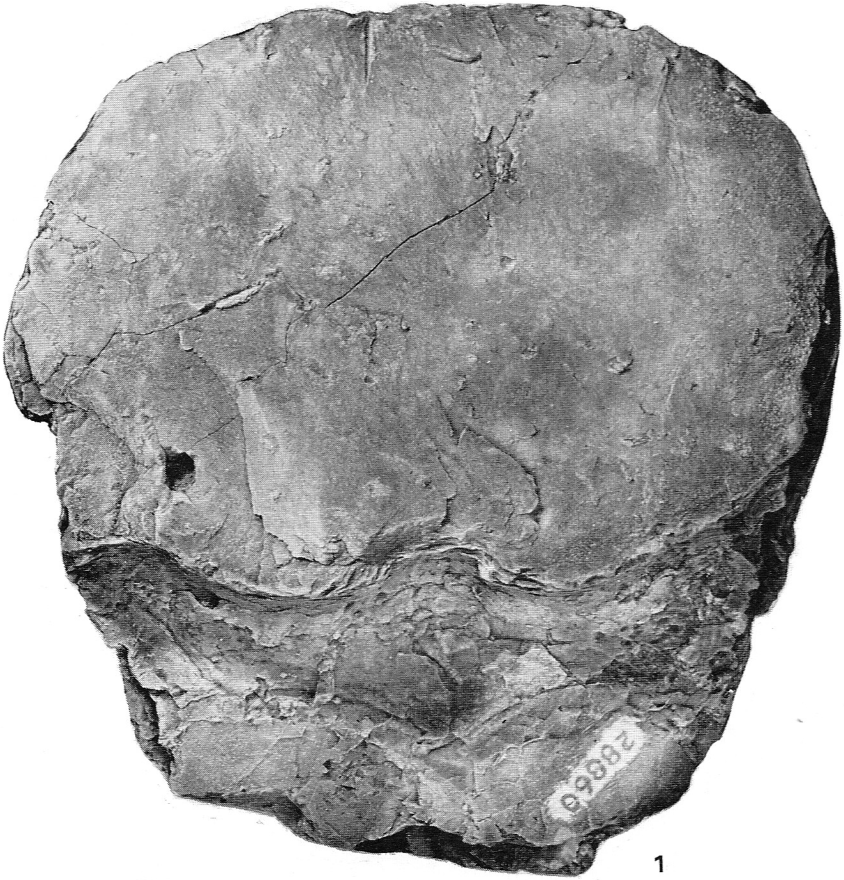
PLATE 1–38

PLATE 1-39.—*Solenochilus*

FIGURE 1. *Solenochilus* sp. Dorsal-end view of the only specimen, showing outline of whorl, X1; Washingtonville unit, loc. MUmu-1; OSU 28860.

2. *Solenochilus cambridgensis* Frontz. Section view through test showing details of corrugations, X1; Cambridge unit, loc. Gwe-1; OSU 29266.



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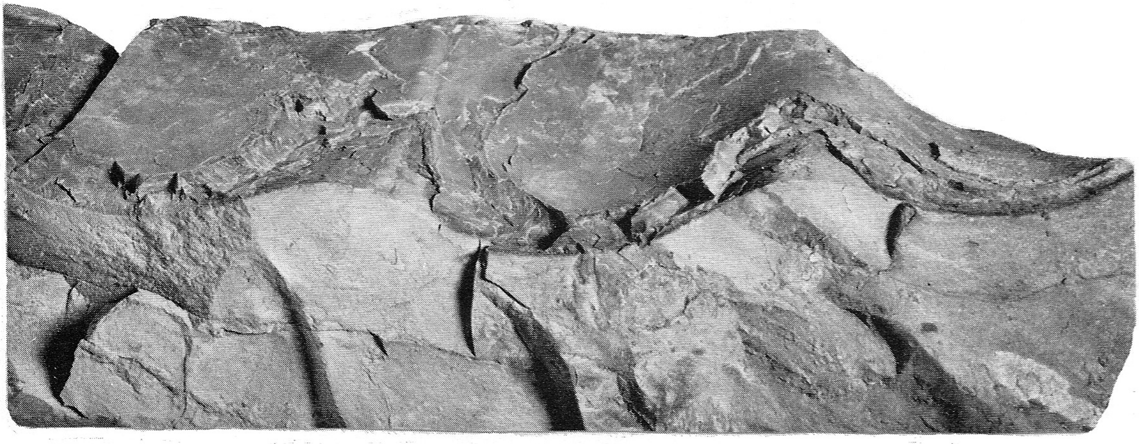

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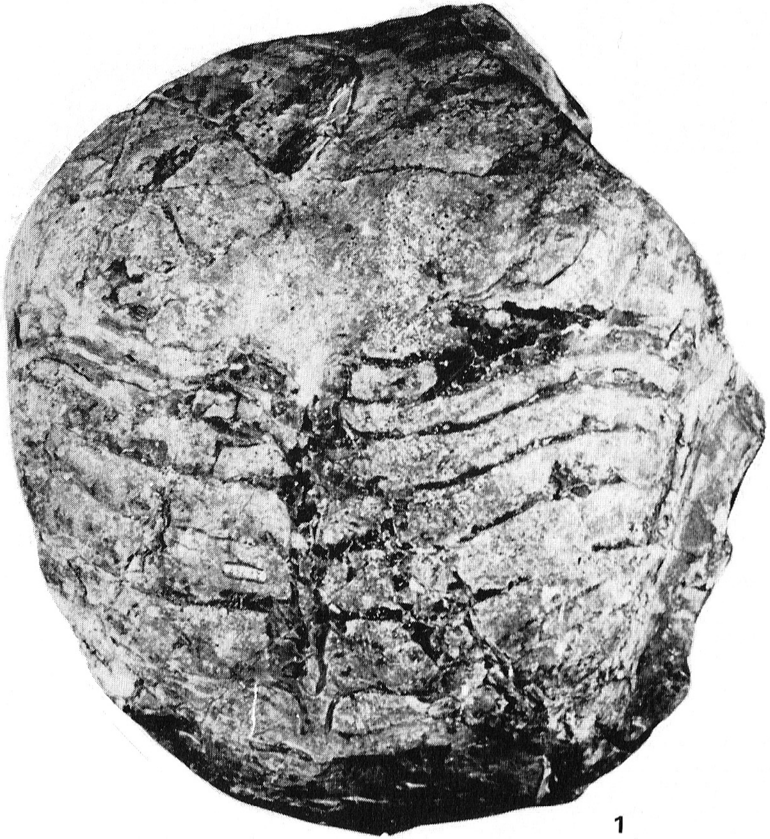
PLATE 1–39

PLATE 1-40.—*Solenochilus cambridgensis* Frontz

FIGURES 1, 2. Ventral views of paratypes showing parts of body chamber and phragmocone, including siphuncle and sutures, X¼; Cambridge unit, loc. Gwe-2.

1. Exfoliated incomplete paratype; OSU 26789.
2. Mostly exfoliated incomplete paratype; OSU 26790.



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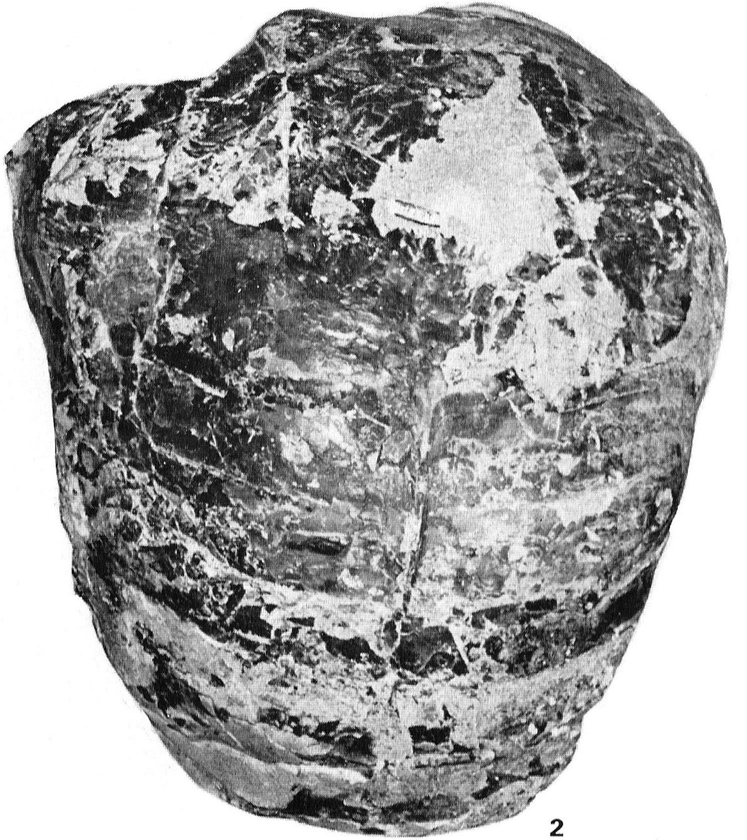

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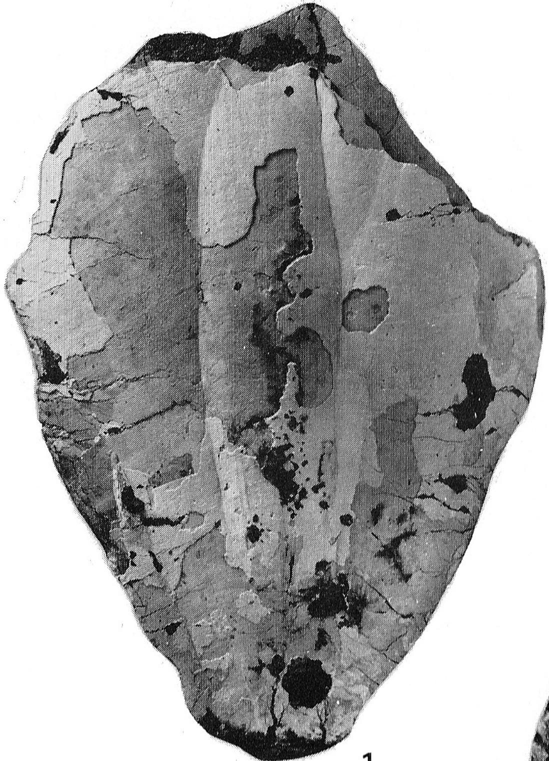
PLATE 1–40

PLATE 1-41.—*Poterioceras curtum* (Meek & Worthen)

FIGURES 1, 2. Ventral (**1**) and dorsal (**2**) views of mashed, partially exfoliated, incomplete specimen showing ornament, X$^{3}/_{4}$; Putnam Hill unit, loc. Td-4; OSU 28818.

3, 5. End (**3**) and lateral (**5**) views of incomplete specimen showing conchal cross section and surface ornament, X1; Columbiana unit, loc. Mg-7; OSU 18746.

4. End view of incomplete specimen showing conchal cross section, X1; Putnam Hill unit, loc. Ms-3; OSU 28819.



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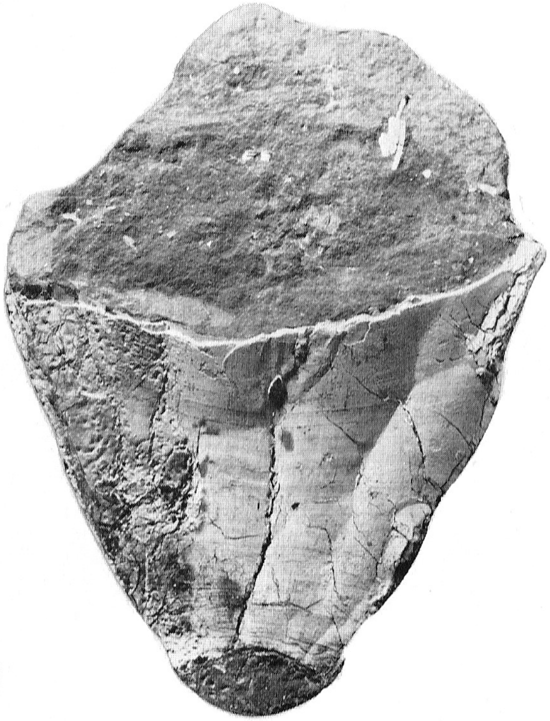

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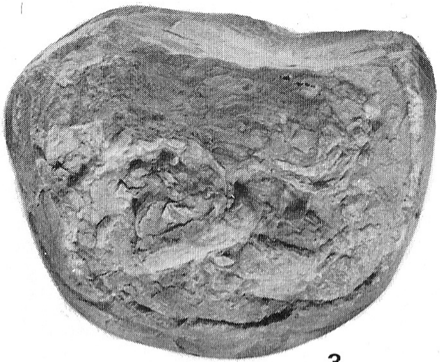

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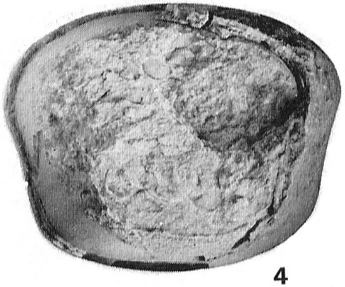

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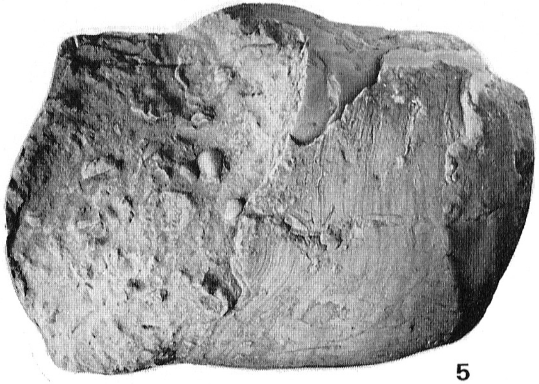

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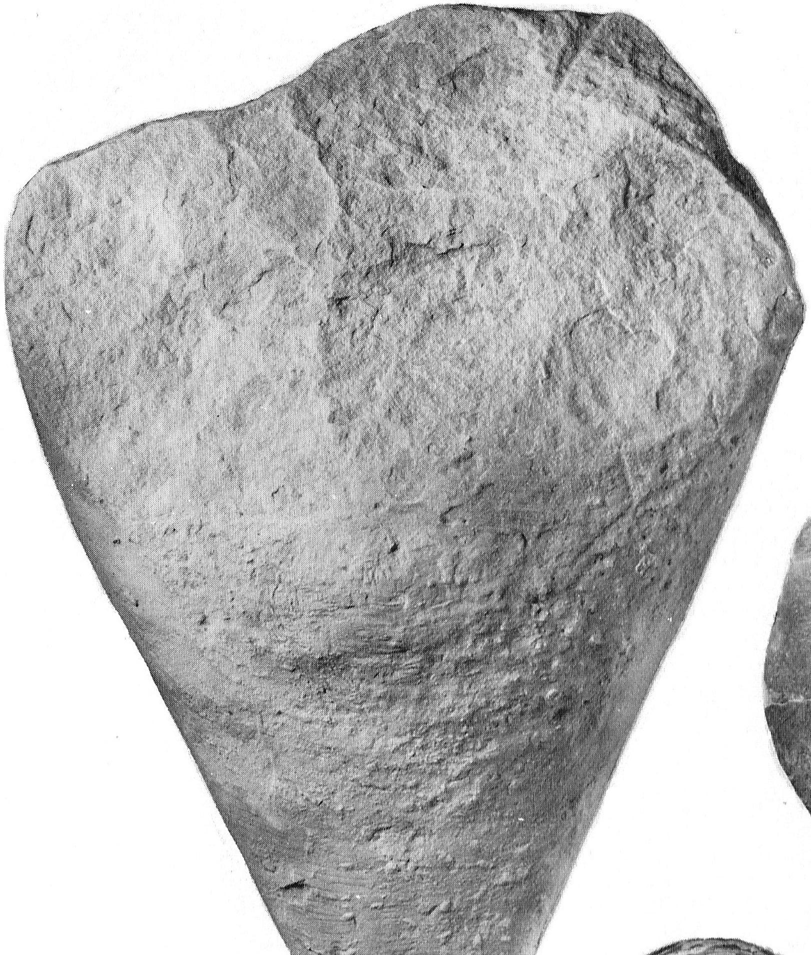
PLATE 1–41

PLATE 1-42.—*Ctenobactrites* and *Poterioceras*

FIGURES 1, 2. *Poterioceras subellipticum* Miller & Unklesbay. Dorsal (**1**) and lateral (**2**) views of incomplete holotype, X1; Wyandotte Formation, loc. N:Cl-1; UNSM IP8341.

3. *Ctenobactrites isogramma* (Meek). Long view of fragmental hypotype showing variation in spacing of surface ornamental lines, X1; Putnam Hill unit, loc. Ty-3; OSU 28803.

4-6. *Poterioceras curtum* (Meek & Worthen).
   4. Ventral view of incomplete hypotype showing surface ornament and trace of sutures, Columbiana unit, loc. Mg-2; OSU 18745.
   5. End view of doubtful incomplete hypotype showing partial outline of conchal cross section, X1; Brush Creek unit, loc. Cma-3; CMNH 3879.
   6. Lateral view of small, doubtful, incomplete hypotype showing long conchal outline and surface ornament, X3; Columbiana unit, loc. Mg-6; SUI 34792.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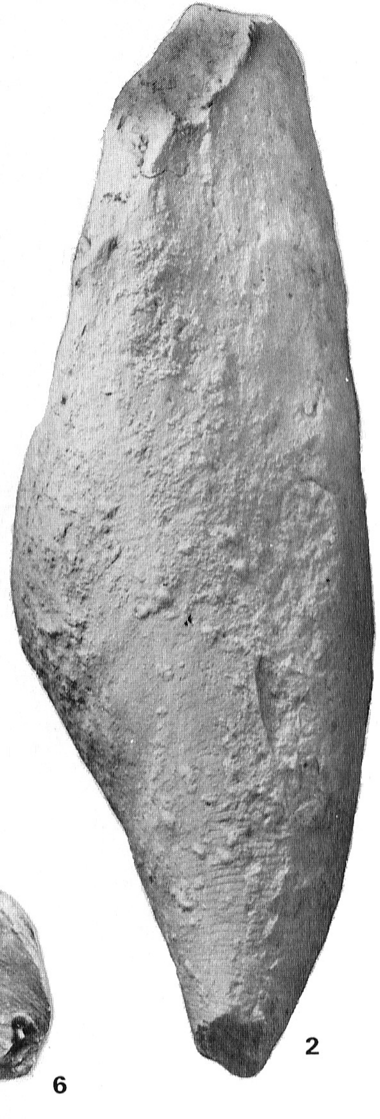
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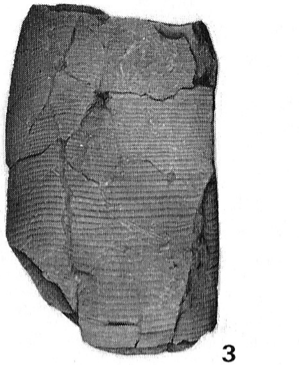
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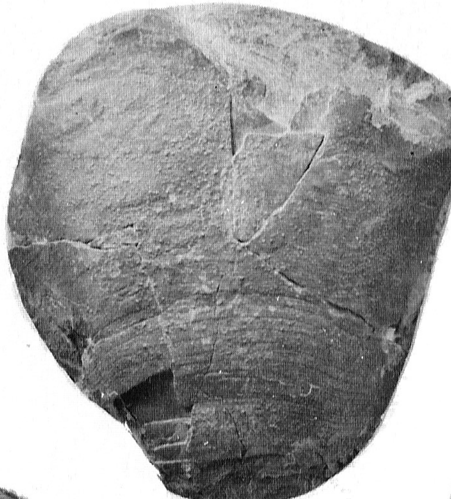
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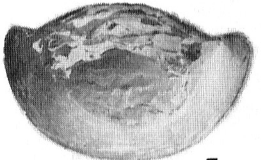
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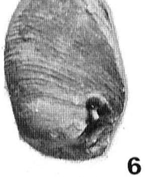
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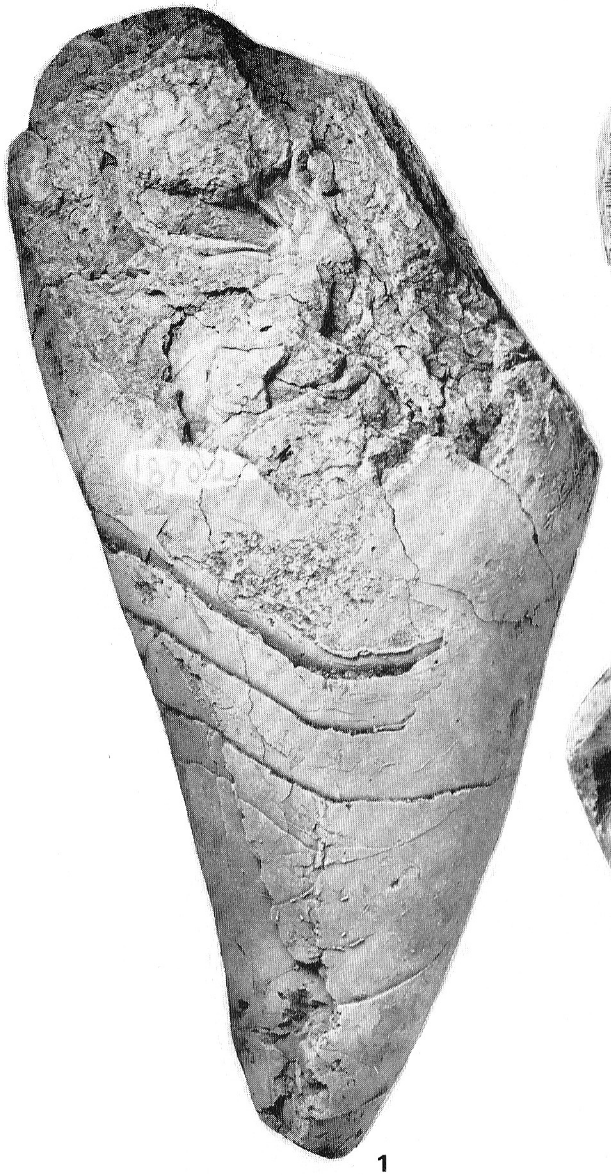
PLATE 1–42

PLATE 1-43.—*Brachycycloceras* and *Poterioceras*

FIGURES 1, 2. *Poterioceras subellipticum* Miller & Unklesbay. Lateral (**1**) and dorsal (**2**) views of distorted, exfoliated, incomplete hypotype showing portions of body chamber and phragmocone, including sutures, X1; Vanport unit, loc. Tl-1; OSU 18702.

3. *Brachycycloceras* sp. External mold of fragment of specimen showing variation in ornament, X1½; Upper Mercer unit, loc. Twy-2; OSU 28806.

4. *Poterioceras curtum* (Meek & Worthen). Ventral view of incomplete specimen showing ornament, X2; Columbiana unit, loc. Mg-2; OSU 19555.



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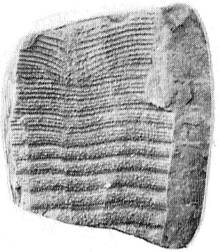

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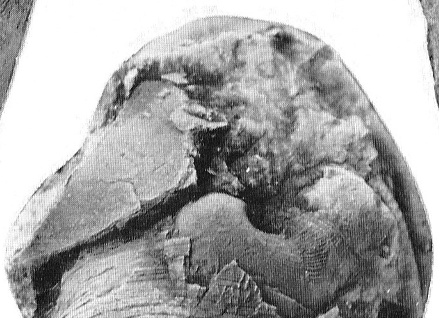

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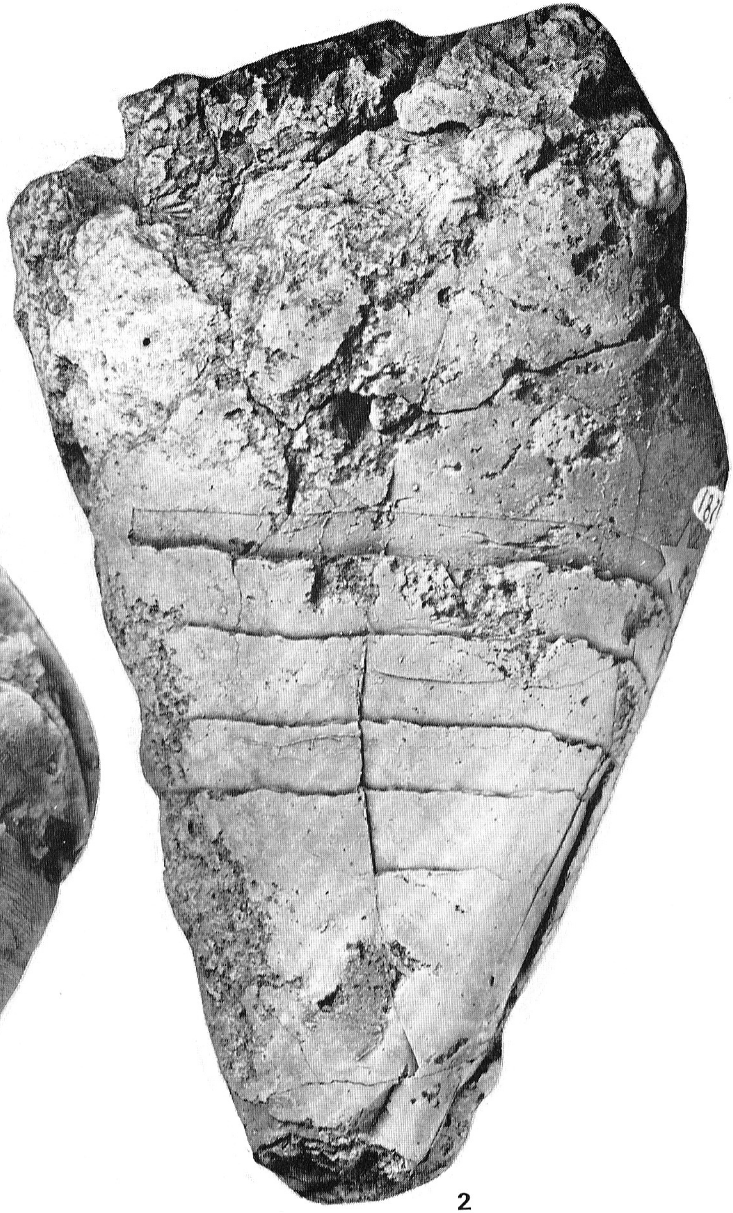

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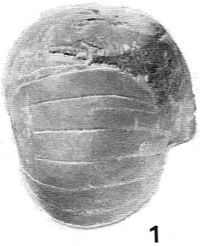
PLATE 1–43

PLATE 1-44.—*Coelogasteroceras* and *Liroceras*

FIGURES 1, 3-12. *Liroceras liratum* (Girty). All X2. (Note: some repository numbers include more than one specimen.)

1. Ventral view of exfoliated hypotype showing ventral part of phragmocone, including sutures; Brush Creek unit, loc. Aa-41; OSU 28830.
3. Lateral view of incomplete hypotype showing ornament on umbilical shoulder; Columbiana unit, loc. Ss-4; OSU 28831.
4. Lateral view of incomplete hypotype showing ornament; Columbiana unit, loc. Mg-2; OSU 18749.
5. Dorsal-end view of incomplete hypotype showing dorsal impression, a septum, and location of siphuncle; Columbiana unit, loc. Mg-10; OSU 18711.
6. Dorsal-end view of incomplete hypotype showing dorsal impression, a septum, and location of siphuncle; Columbiana unit, loc. Cuc-2; OSU 18712.
7. Lateral view of incomplete hypotype showing portions of body chamber and of phragmocone with sutures; Brush Creek unit, loc. Aa-41; OSU 28830.
8. Cut and polished long view of nearly complete hypotype showing body chamber and phragmocone, including septa and umbilical perforation; Columbiana unit, loc. Mg-7; OSU 18710.
9. Cut and polished transverse view of hypotype showing whorl sections and inner whorl; Columbiana unit, loc. Mg-7; OSU 18710.
10. Ventral view of partially exfoliated hypotype showing parts of body chamber and phragmocone, including septa and conchal furrow ridge; Columbiana unit, loc. Mg-7; OSU 18710.
11. Ventral view of incomplete hypotype showing growth lines and outline of hyponomic sinus; Brush Creek unit, loc. Aa-41; OSU 28830.
12. Ventral view of incomplete and damaged hypotype showing growth lines and outline of hyponomic sinus; Columbiana unit, loc. Ss-4; OSU 28831.

2. *Coelogasteroceras dubium* Miller & Unklesbay. Ventral-apertural view of hypotype showing whorl section and midventral groove, X1$^{3}/_{4}$ (approx.); Brush Creek unit, loc. Cma-3; USNM 161421.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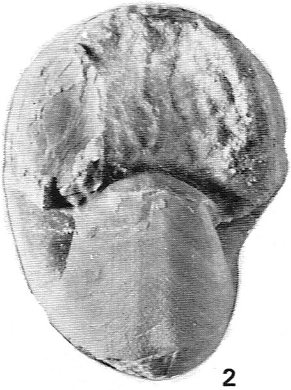
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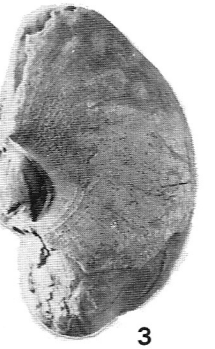
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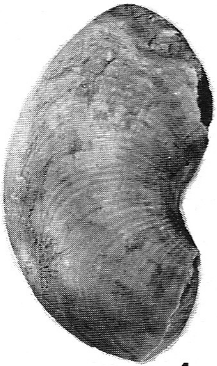
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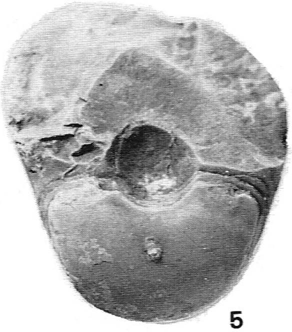
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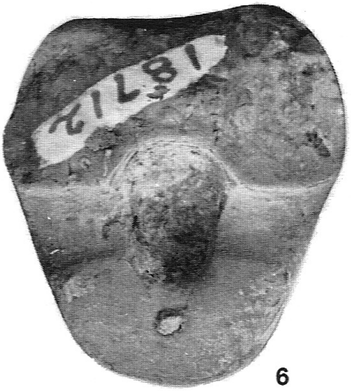

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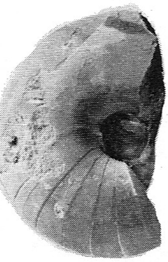
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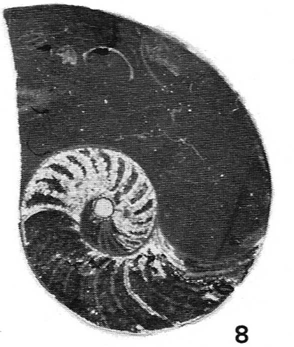
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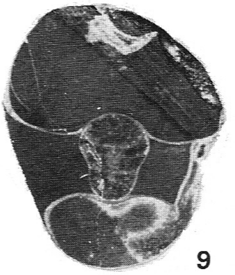
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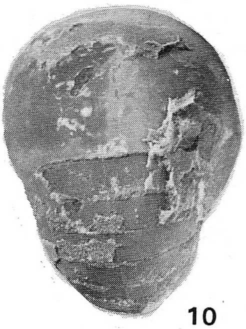
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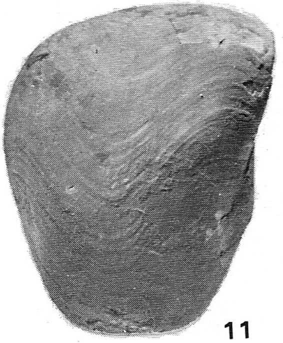
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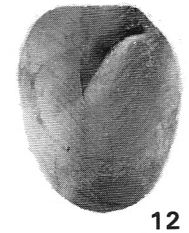
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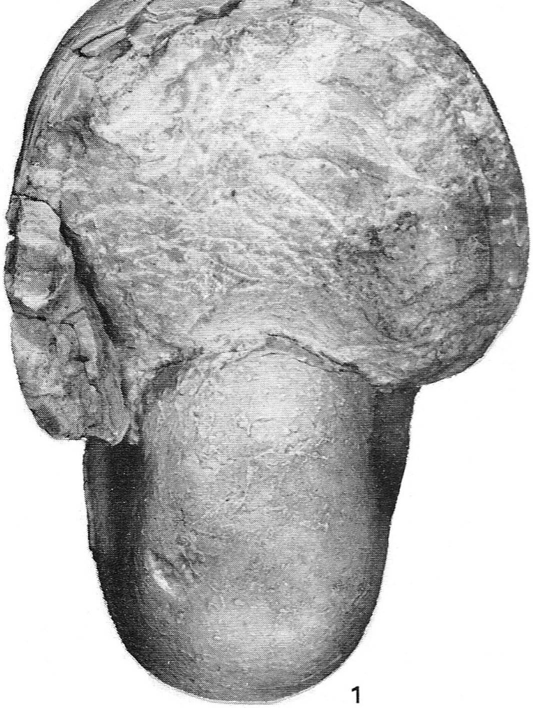
PLATE 1–44

PLATE 1-45.—*Condraoceras*

FIGURES 1, 4. *Condraoceras primum* Miller, Lane & Unklesbay. Ventral-apertural (**1**) and lateral (**4**) views of incomplete hypotype, X1; Cambridge unit, loc. Gwe-1; OSU 28833.

2, 3. *Condraoceras*? sp. Lateral (**2**) and dorsal-end (**3**) views of incomplete specimen, X1; Vanport unit, loc. Tl-1; OSU 18733.



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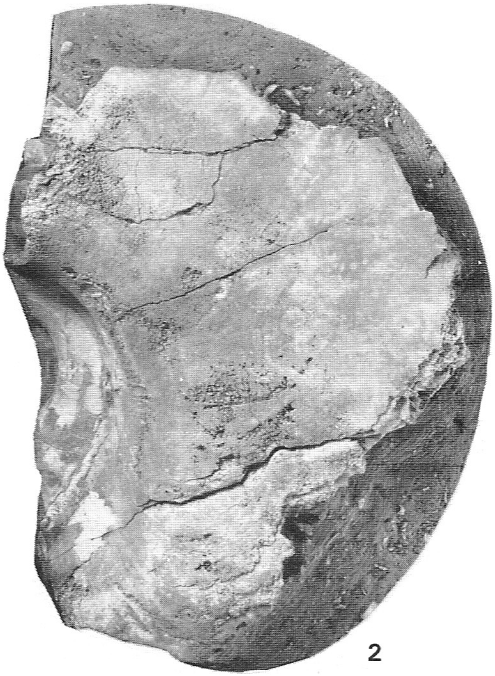

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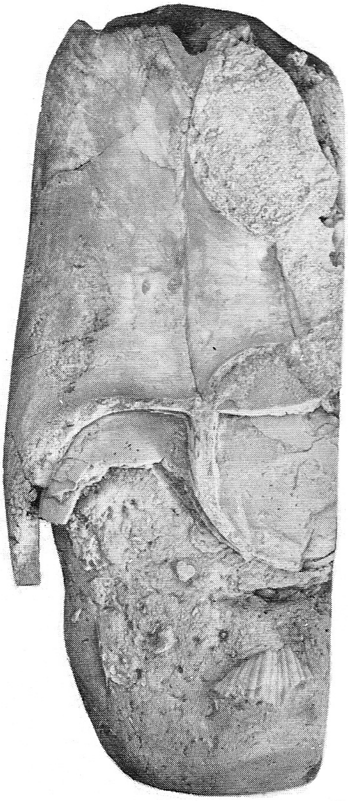

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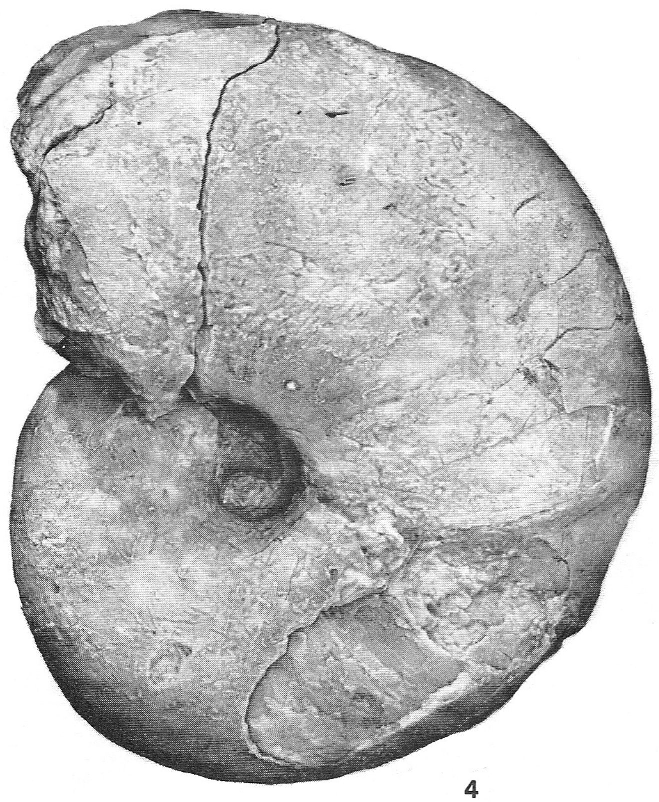

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PLATE 1–45

PLATE 1-46.—*Ephippioceras*, *Megaglossoceras*, and *Stenopoceras*

FIGURES 1-5, 7, 9. *Ephippioceras ferratum* (Cox). All X1, except **9**.

1, 2, 7. Dorsal (**1**), ventral (**2**), and lateral (**7**) views of incomplete hypotype showing dorsal impression, septum, and whorl cross section (**1**), outer surface and possibly hyponomic sinus (**2**), and umbilicus (**7**); Columbiana unit, loc. Mg-7; OSU 18708.

3. Polished long view of phragmocone of hypotype showing septa and siphuncle and part of body chamber; Columbiana unit, loc. Mg-7; OSU 18708.

4. Ventral view of largely exfoliated incomplete hypotype showing ventral suture pattern; Putnam Hill unit, loc. Ms-3; OSU 29149.

5. Ventral view of small exfoliated fragmental hypotype showing ventral suture pattern; Vanport unit, loc. Vs-3; OSU 28835.

9. Ventral view of exfoliated incomplete hypotype showing ventral suture pattern, X2; Columbiana unit, loc. Mg-10; OSU 18709.

6. *Stenopoceras smithi* Miller & Unklesbay. Lateral view of exfoliated incomplete paralectotype showing umbilicus and portions of body chamber and of phragmocone, including lateral suture pattern, X1; Ames unit, loc. At-67; SUI 8174B.

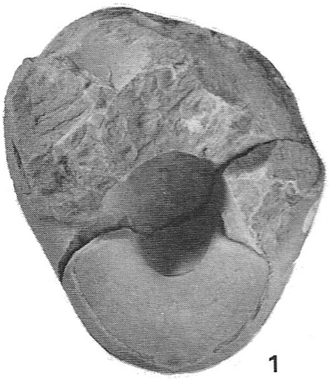
8, 10-12. *Megaglossoceras* spp. All X1.

8. Ventral view of exfoliated fragment of phragmocone showing ventral suture pattern; Brush Creek unit, loc. Aw-51; OSU 28838.

10. Ventral view of exfoliated fragment of phragmocone showing ventral suture pattern; Vanport unit, loc. Mp-1; OSU 28840.

11. Ventral view of exfoliated fragment of phragmocone showing small portion of ventral suture pattern; Putnam Hill unit, loc. Mc-2; OSU 28839.

12. Ventral view of partially exfoliated fragment of phragmocone showing midventral saddle and first lateral lobe of ventral suture pattern; Brush Creek unit, loc. Aa-41; OSU 28837.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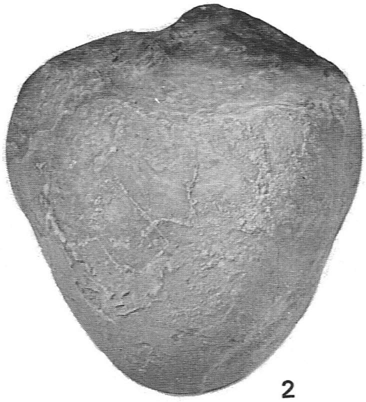
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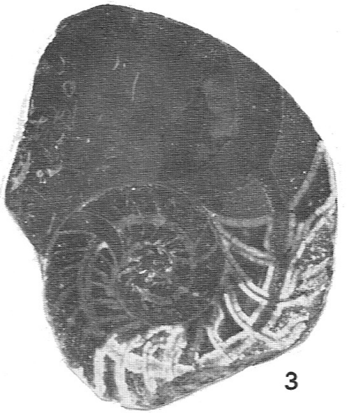
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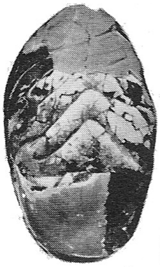
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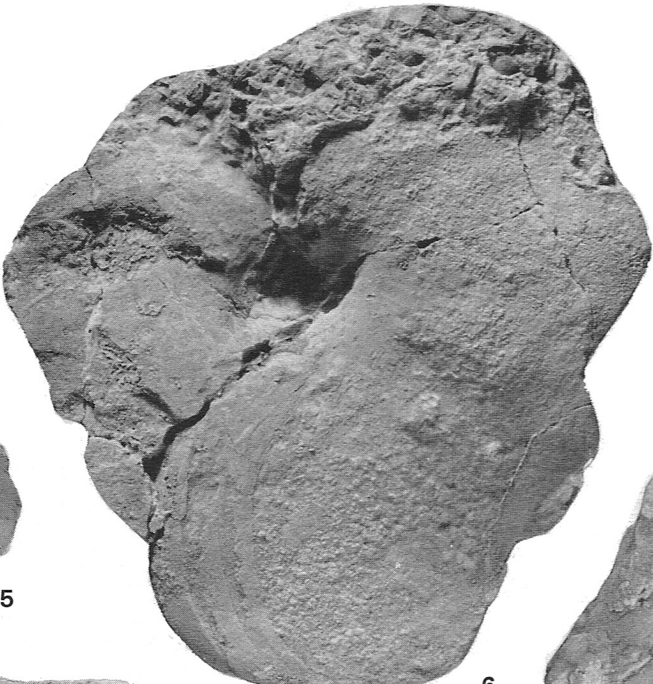
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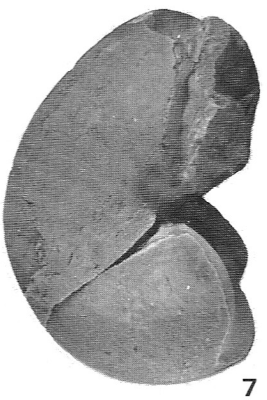
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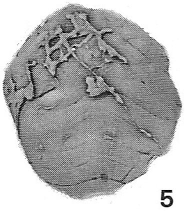
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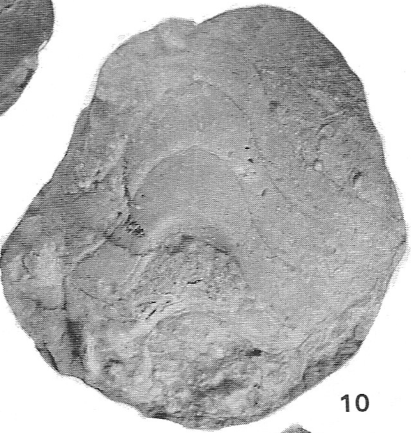
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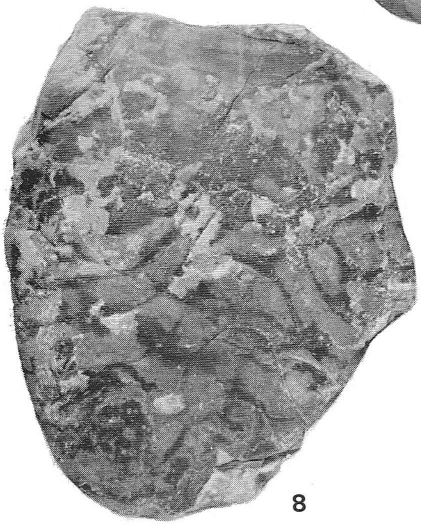
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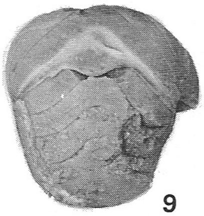
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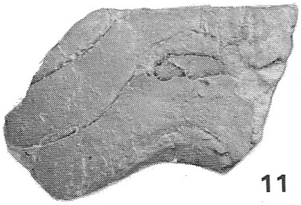
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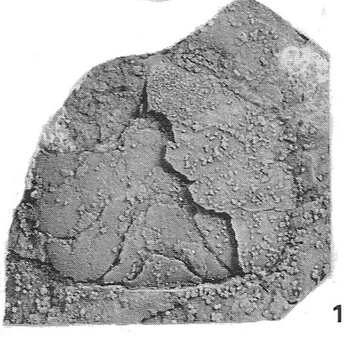
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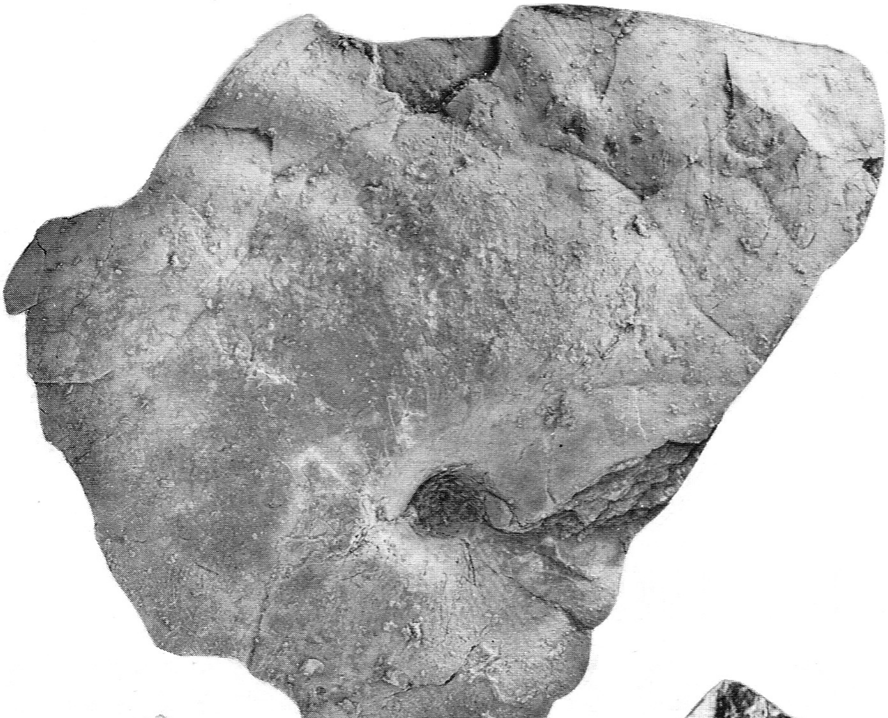
PLATE 1–46

PLATE 1-47.—Genera indeterminate

FIGURE 1. Genus indeterminate #2 sp. Lateral view of a flattened incomplete specimen showing surface, lateral corrugations, and umbilicus, X1; Brush Creek unit, loc. Aa-41; OSU 29309.

2, 3. Genus indeterminate #1 sp. Lateral and ventral views of slightly distorted, exfoliated, incomplete phragmocone showing septa and traces of nodes, $X^{9}/_{10}$ (approx.); Putnam Hill unit, loc. Vel-15; OSU 28969.



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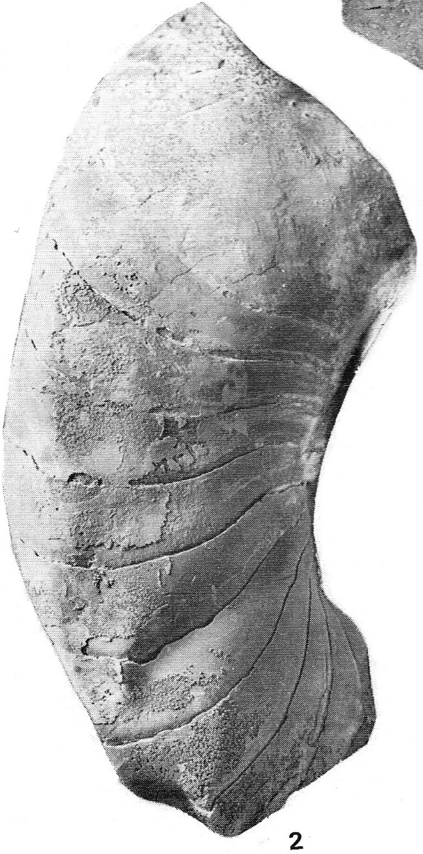

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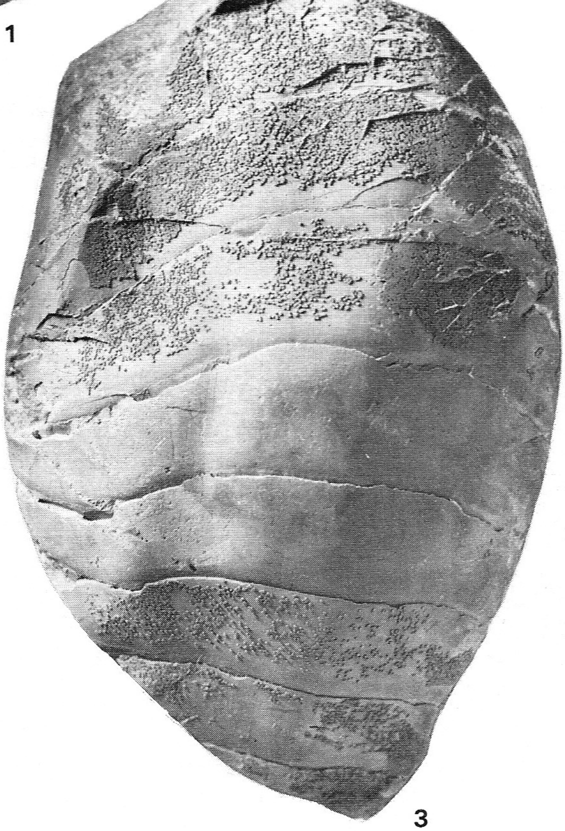

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PLATE 1–47

STATE OF OHIO
George V. Voinovich, Governor
DEPARTMENT OF NATURAL RESOURCES
Donald C. Anderson, Director
DIVISION OF GEOLOGICAL SURVEY
Thomas M. Berg, Chief

BULLETIN 71

PENNSYLVANIAN CEPHALOPODS OF OHIO

PART 2
AMMONOID CEPHALOPODS

by

Royal H. Mapes
Delbert L. Windle
Myron T. Sturgeon
and
Richard D. Hoare

Columbus
1997

Chapter 2-1

INTRODUCTION

LOCATION AND EXTENT OF STUDY AREA

This study concerns the ammonoid cephalopods that have been recovered from the marine units of the Pennsylvanian System in Ohio. The marine units are exposed in all or parts of 33 counties in the eastern part of the state from Lake County in the north to Lawrence County in the south (fig. 2-1).

Differences in depositional environments that have been observed in the marine units almost certainly affected the overall composition and distribution of invertebrate faunas in Ohio and in the Appalachian Basin as a whole. Thus, some faunal differences must be expected in the Pennsylvanian strata that are exposed in areas, such as the Midcontinent (primarily Arkansas, Kansas, Oklahoma, and Texas), outside Ohio. The rocks of the Pennsylvanian System in Ohio lie on the western margin of the Appalachian Basin and form part of the Appalachian Plateaus of the central Appalachian Mountains.

PURPOSE AND SCOPE OF INVESTIGATION

The major purpose of this investigation is to determine the taxonomic diversity and stratigraphic distribution of the ammonoid cephalopods recovered from Pennsylvanian strata of Ohio. Because this group of animals is considered to be excellent for biostratigraphic correlation, an attempt was made to correlate ammonoid faunas of similar age from the Midcontinent region of North America and elsewhere. However, it became apparent during this study that a great deal of detailed systematic work on Midcontinent ammonoid specimens must be accomplished before detailed biostratigraphic correlations can be made. Thus, the conclusions regarding correlations reported herein must be considered tentative.

Another aim of this study is to examine the paleobiogeographic distribution of the ammonoids in Ohio. Rigorous treatment of the genera and species reported herein is limited in regard to distribution because, in comparison to the abundant and diverse ammonoid faunas recovered in the Midcontinent, the Ohio ammonoids are relatively scarce in numbers of specimens and moderate to low in diversity at most collecting localities. The nomenclatural instability of some of the ammonoid genera and species also has hindered analysis. Therefore, only general statements regarding paleobiogeography and provincialism of some ammonoid taxa are possible at this time.

Evolutionary trends detected within the various genera and species of ammonoids recovered from Pennsylvanian strata in Ohio will undoubtedly prove to be extremely important in deciphering the phylogenesis of Pennsylvanian ammonoids in the Midcontinent and elsewhere. In Ohio, the stratigraphic succession of marine units is well known, and any ammonoid genus recovered from two or more marine units can be placed in a relative time sequence. Because of this relative time sequence, any morphological change detected at the species level may well reflect partial phylogeny of the genus and associated species.

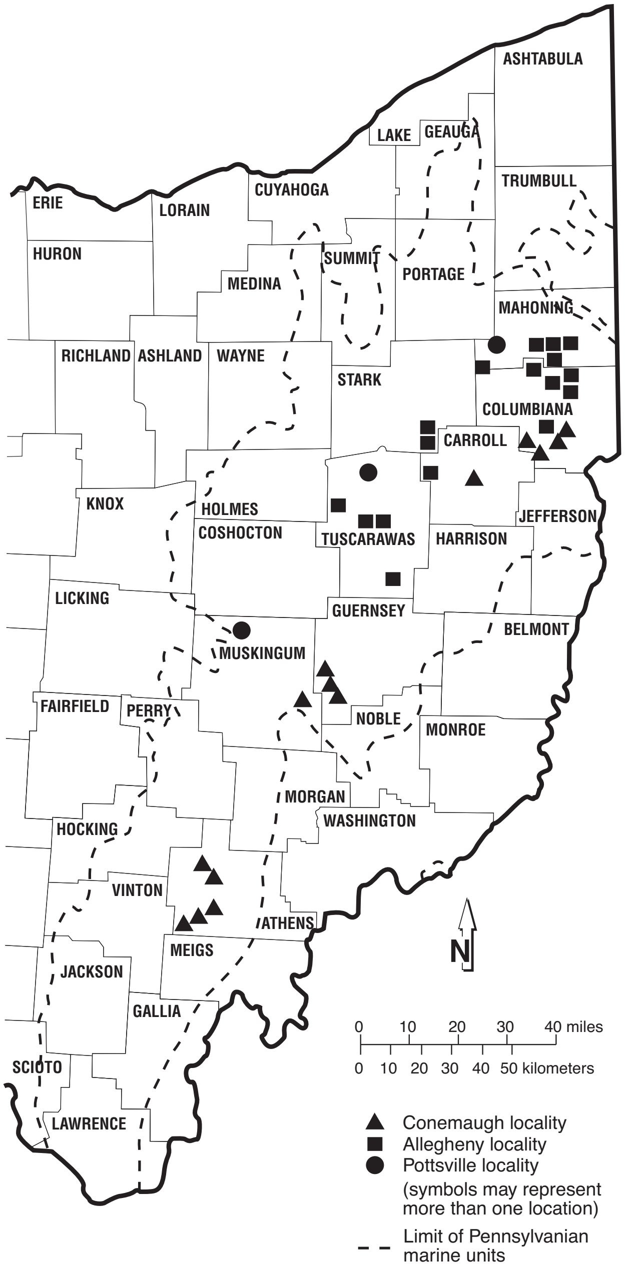


FIGURE 2-1.—Map of eastern Ohio showing collecting localities for Pennsylvanian ammonoid cephalopods.

In the Midcontinent region, detailed stratigraphic relationships of isolated ammonoid-bearing localities commonly are uncertain. The depositional framework for that region is complicated by multiple sediment sources, delta complexes, basin and shelf development, and mountain building, providing at certain times and places an as yet undeciphered detailed stratigraphic history. This complexity tends to blur the relationships of the isolated ammonoid- bearing exposures in terms of detailed biostratigraphy and evolutionary relationships of the ammonoids and other faunal components. Because of this complexity, the evolutionary changes detected in Ohio ammonoids provide a potential guideline for the eventual determination of the phylogenies of many Pennsylvanian ammonoid lineages.

It is hoped that this information will aid workers in future studies of Pennsylvanian ammonoids. Continued collecting of ammonoids together with the associated faunas will undoubtedly allow a more complete assessment of the Pennsylvanian marine biota in the Appalachian Basin.

METHOD OF INVESTIGATION

Collections of Pennsylvanian invertebrate fossils accumulated over a 40± year span of intensive collecting in Ohio form the major part of the material used in this investigation. Despite the intensive collecting, only 276 ammonoid specimens have been recovered, although there are approximately 60,000 invertebrate fossils in the collections. The ammonoids were recovered from localities in the Pottsville, Allegheny, and Conemaugh Groups (table 2-1 and Appendix B).

For comparative purposes, type specimens were borrowed from a number of institutions. In some cases, visits to extensive collections were necessary to examine described and undescribed material. Previously published ammonoid material from Ohio was reexamined. A collection of more than 25,000 cephalopods from Pennsylvanian strata in the Midcontinent area was used as comparative material when this report was being prepared. This collection is estimated at more than 200,000 specimens as of 1997 and has been under study by Mapes, his students, and colleagues (see, for example, Mapes and Bergstein, 1987; Mapes and Boardman, 1988; Boardman, Mapes, and Work, 1989a, 1989b; Mapes and Boardman, 1992; Boardman, Work, Mapes, and Barrick,1994; Tanabe, Landman, and Mapes, 1994; Mapes, Sims, and Boardman, 1995).

Some of the specimens in the Ohio collections were so poorly preserved or so juvenile that species and/or genus identification is impossible. Brief descriptions of these specimens are included at the end of Chapter 2-4. All of the Ohio ammonoid specimens that form the basis of this report have been placed in the repository of Orton Geological Museum at The Ohio State University or in the Department of Geology at the University of Iowa.

Repository abbreviations and addresses are listed below.

CM	Carnegie Museum of Natural History, 4400 Forbes Ave., Pittsburgh, PA 15213
OSU	Orton Geological Museum, Department of Geological Sciences, The Ohio State University, Columbus, OH 43210
SUI	Department of Geology, State University of Iowa, Iowa City, IA 52242
TUP	Department of Geological Sciences, University of Texas, Austin, TX 78712

Systematic designations above generic rank generally conform to those provided by Miller, Furnish and Schindewolf (1957) and/or Ruzhencev (1962). Where necessary, conflicts have been resolved in favor of Ruzhencev (1962) and by using later published works by several authorities, including but not limited to Nassichuk (1975) and Ruzhencev and Bogoslovskaya (1971, 1978). Our classification hierarchy for the subclass Ammonoidea is outlined below:

- Order Goniatitida Hyatt, 1884
  - Suborder Tornoceratina Wedekind, 1918
    - Superfamily Cheiloceratаceae Frech, 1897
      - Family Pseudohaloritidae Ruzhencev, 1957b
        - Genus *Neoaganides* Plummer & Scott, 1937
  - Suborder Goniatitina Delépine, 1952
    - Superfamily Somoholitaceae Ruzhencev, 1938
      - Family Pseudoparalegoceratidae Librovich, 1957
        - Genus *Phaneroceras* Plummer & Scott, 1937
      - Family Somoholitidae Ruzhencev, 1938
        - Genus *Somoholites* Ruzhencev, 1938
    - Superfamily Neodimorphocerataceae Furnish & Knapp, 1966
      - Family Neodimorphoceratidae Furnish & Knapp, 1966
        - Genus *Dimorphoceratoides* Furnish & Knapp, 1966
    - Superfamily Gastriocerataceae Hyatt, 1884
      - Family Gastrioceratidae Hyatt, 1884
        - Genus *Gastrioceras* Hyatt, 1884
    - Superfamily Schistocerataceae Schmidt, 1929
      - Family Schistoceratidae Schmidt, 1929
        - Genus *Paralegoceras* Hyatt, 1884
        - Genus *Eoschistoceras* Ruzhencev, 1952
        - Genus *Schistoceras* Hyatt, 1884
        - Genus *Paraschistoceras* Plummer & Scott, 1937
      - Family Welleritidae Plummer & Scott, 1937
        - Genus *Wellerites* Plummer & Scott, 1937
    - Superfamily Goniolobocerataceae Spath, 1934
      - Family Wiedeyoceratidae Ruzhencev & Bogoslovskaya, 1978
        - Genus *Pennoceras* Miller & Unklesbay, 1942
      - Family Gonioglyphioceratidae Ruzhencev & Bogoslovskaya, 1978
        - Genus *Gonioglyphioceras* Plummer & Scott, 1937
        - Genus *Mangeroceras* Sturgeon, Windle, Mapes & Hoare, 1982
      - Family Goniolobоceratidae Spath, 1934
        - Genus *Gonioloboceras* Hyatt, 1900
    - Superfamily Neoicocerataceae Hyatt, 1900
      - Family Neoicoceratidae Hyatt, 1900
        - Genus *Glaphyrites* Ruzhencev, 1936
    - Superfamily Shumarditaceae Plummer & Scott, 1937
      - Family Parashumarditidae Boardman, Work & Mapes, 1994
        - Genus *Aktubites* Ruzhencev, 1955
    - Superfamily Marathonitaceae Ruzhencev, 1938
      - Family Marathonitidae Ruzhencev, 1938
        - Genus *Kargalites* Ruzhencev, 1938

PREVIOUS INVESTIGATIONS

General surveys of Pennsylvanian ammonoids were presented by Miller and others (1957) and Ruzhencev (1962). These studies deal with morphology, growth, phylogeny, evolution, paleoecology, and classification. Lehmann (1976) published an extremely interesting generalized work on ammonoids; he published a second general work in 1992. The proceedings of a symposium on the Ammonoidea, edited by House and Senior, was published in 1981; presumably this work will lead toward the revision of the ammonoid volume (Arkell and others, 1957) of the Treatise on Invertebrate Paleontology. Besides these generalized works, numerous smaller reports and monographs have been published.

Previous studies concerning Pennsylvanian ammonoids in eastern Ohio and adjacent areas are few. The first report was that of Morton (1836), who named, briefly described, and crudely illustrated *Schistoceras* from the Cambridge unit in Guernsey County, Ohio. Later workers, including Meek (1871a, 1871b), Whitfield (1882, 1893), Mark (1912), and Morningstar (1922), provided more-or-less comprehensive studies of marine invertebrate fossils, but made no mention of ammonoids. Miller and Unklesbay (1942, 1947) published a paper and supplement on Conemaugh cephalopods in Pennsylvania and Ohio. These authors recognized three genera and four species; all but one of these have now been recovered and identified from Ohio. Miller and Sturgeon (1946) and Sturgeon and Miller (1948) reported six genera and species from Ohio; all but one of these taxa were from the Allegheny Group. In 1971 Saunders redescribed one of these taxa. In eastern Kentucky, Miller and Faber (1892) and Miller and Gurley (1896) reported three species of ammonoids from the "Coal Measures, on Elkhorn Creek." More than 70 years later, Furnish and Knapp (1966) redescribed and summarized the ammonoid fauna, which included four genera and species, from the Kendrick shale in the Breathitt Formation in Kentucky. Sturgeon and others (1982) described new cephalopods from the Pennsylvanian of Ohio; they named a new genus and species of ammonoid from the Putnam Hill unit (Allegheny Group) and possibly from the Lowellville (Poverty Run) unit (Pottsville Group). Windle's unpublished M.S. thesis (1970) includes descriptions of five genera and six species. Recently, Davis and Mapes (1996) provided an overview of Ohio cephalopods; the section on Pennsylvanian cephalopods is based on the work in this bulletin.

AMMONOIDS—A GENERAL DISCUSSION

A highly specialized terminology has been developed to deal with the morphological variation observed in ammonoids. Arkell, Kummel, Miller, and Wright (1957, p. L2-L6) provided a detailed glossary of morphological terms applied to ammonoid hard parts. With some modifications, this glossary list is included in Appendix C of this bulletin.

Overall, there are three extremely important characteristics that must be considered when identifying a Paleozoic ammonoid: suture pattern, conch form, and ornamentation. For many years, numerous ammonoid authorities have attempted to devise formulas to describe the configuration of suture patterns. The currently accepted rules for such formulas were described by Ruzhencev (1949, 1957b, 1960, 1962). The following symbols are extracted from his work:

D = dorsal lobe;
I = internal lateral lobe;
L = external lateral lobe;
U = umbilical lobe ;
U_2 = subdivision of umbilical lobe giving rise to a new secondary umbilical saddle;
U^2 = umbilical lobe that ontogenetically arises near the apex of the umbilical saddle;
V = ventral lobe;
( ) = lobes or sutural complexes that are not entirely separated or distinct;
: = position of the umbilical seam.

An example of a formula is illustrated in figure 2-2C. Use of these symbols must be precise; the reader is referred to Ruzhencev (1962) for the rules and guidelines for application.

Sutural configurations are known to change during ontogeny. General sutural trends during growth include attenuation, inflation, and addition of sutural elements. These changes are extremely important in determining taxonomic affinities and phylogenies. When analyzing sutural configurations, it is important to compare specimens of equal size, as it is assumed (probably incorrectly in many cases) that two equal-sized specimens are at the same stage of growth and that significant differences detected in suture pattern are of taxonomic importance. This technique essentially ignores problems of population variation and dwarfism.

The description of the overall conch form is an important aspect of describing an ammonoid. Figure 2-2 illustrates some important morphological features and the basic scheme used in measuring a conch. Of particular importance are conch diameter (D); whorl height (H); whorl width (W); maximum umbilical diameter (Umax), measured from umbilical shoulder to shoulder; and minimum umbilical diameter (Umin), measured from umbilical seam to seam. Because these parameters commonly change during growth of the animal, it is extremely important when comparing one conch to another that size equivalence be considered.

Ornament on Pennsylvanian ammonoids can differ greatly between species and can be used for species determination and phylogenetic interpretations. Ribbing is present on many taxa; however, these ribs can become obsolete during the growth of the animal. Growth lines may be difficult to distinguish from ornament because many ammonoids have simple transverse patterns across the conch. Normally, transverse ornament outlines the presence or absence of the hyponomic and ocular sinuses; however, some taxa do not show such sinuosity of the ornament. The presence or absence of ornament sinuosity can be vital in determining taxonomic affinities and phylogenies, as there is an implied difference in soft-part morphology.

ACKNOWLEDGMENTS

We are grateful to the repository staffs of The Ohio State University, the State University of Iowa, the University of Kansas, the University of Oklahoma, and the University of Texas for providing access to relevant specimens for comparative purposes. Mr. and Mrs. Lloyd J. Millhorn of Sherrodsville, Ohio, provided a substantial number of critical specimens and for this we extend our sincere thanks. Thanks are extended to many students, friends, and associates who devoted time and effort in collecting specimens. Jennifer A. Lane of the American Museum of Natural History assisted with translation of some of the foreign reference citations.

The Ohio University Fund provided partial support in the form of supplies, travel expenses, and drafting aid through the Cartographic Center at Ohio University. Some of this research was supported by several grants from the Ohio University Research Committee. Additional support was provided by the Petroleum Research Fund, administered by the American Chemical Society.

We are grateful to the geology departments of Ohio University and Bowling Green State University for their support of this research. We are also indebted to the Ohio Department of Natural Resources, Division of Geological Survey for its support in the preparation and publication of this report. We are especially grateful to Survey Editor Merrianne Hackathorn for her patience, dedication, and attention to detail.

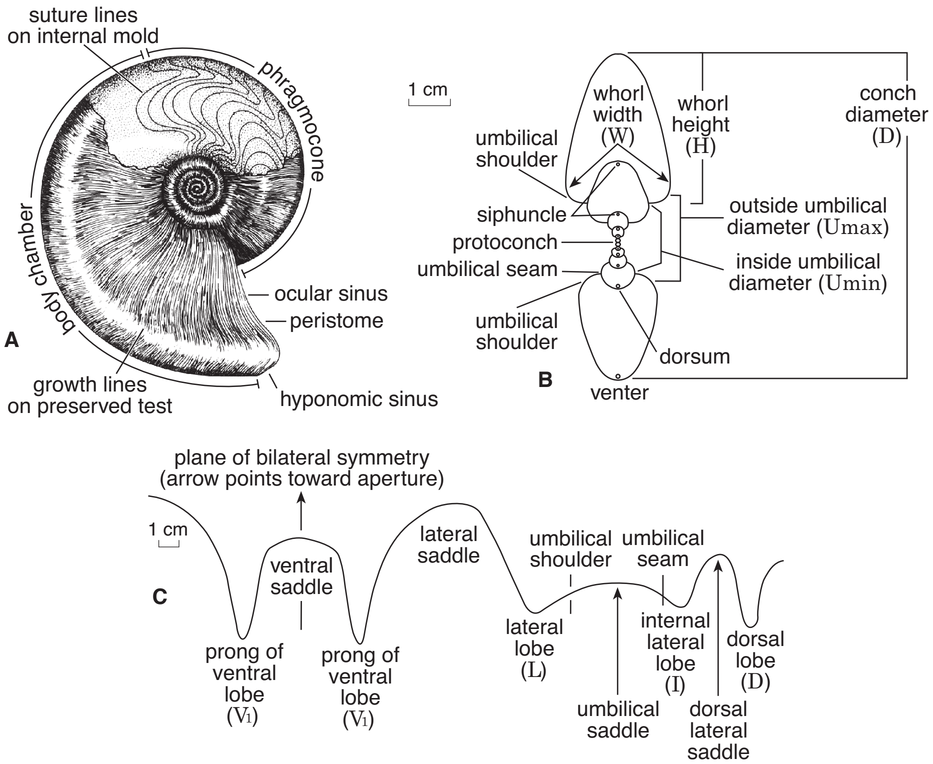


FIGURE 2-2.—Diagrammatic illustrations of some of the morphological features of ammonoid cephalopods. Modified from Miller and Furnish (1957).

A, side view of conch showing growth lines on exterior of preserved test, which form the hyponomic and ocular sinuses, and sutures on internal mold.

B, cross-sectional view showing the positions of conch diameter (D), whorl height (H) and width (W), outside umbilical diameter (Umax), and inside umbilical diameter (Umin).

C, sutural diagram showing features such as prongs of ventral lobe, lateral lobe, etc. Letters indicate the sutural elements that make this formula: $(V_1V_1)L{:}ID$. Diagrams of sutural outlines in this figure and subsequent figures denote the location of the umbilical shoulder as a dashed line and the location of the umbilical seam as a solid line. The arrow indicates the plane of bilateral symmetry and points toward the aperture. On some subsequent figures (for example, fig. 2-9), a zigzag line indicates specimen is broken and the suture is incomplete.

Chapter 2-2

RELATIONSHIP OF AMMONOIDS TO STRATIGRAPHY IN OHIO

The overall sequence of Pennsylvanian strata in Ohio has been extensively studied and analyzed since the first report by Hildreth (1836). Subsequent summaries have been provided by Stout (1939), Sturgeon and Hoare (1968), and Hoare, Sturgeon and Kindt (1979). Part 1 of this bulletin summarizes the Pennsylvanian stratigraphy of Ohio (see p. 5-10 and table 1-1). Our discussion here is limited to the marine units that contain ammonoids.

Of the more than 60,000 Pennsylvanian-age invertebrate fossils in the available Ohio collections, only 276 specimens are ammonoid cephalopods, or less than 0.005 percent of the total number of specimens. Considering that the first ammonoid was described from Ohio in 1836, it is quite clear that ammonoid cephalopods are comparatively rare in the Pennsylvanian marine strata in Ohio.

The ammonoid cephalopods described herein have been recovered from 34 localities in eight counties (see Appendix B for locality descriptions). Exposures of Pennsylvanian marine strata have been mapped in 33 counties in Ohio, yet less than one-fourth of the counties have yielded ammonoids. This low recovery percentage would suggest that additional collecting in the remaining 25 counties could produce some ammonoids (although not great numbers). However, this theory probably cannot be substantiated, as more than 400 collecting localities are known in the 33-county area.

DIVERSITY AND NUMBERS OF OHIO AND MIDCONTINENT AMMONOIDS

Seventeen genera of ammonoids have been identified from the 276 specimens in the Ohio collections; 95 specimens are too fragmentary or juvenile to allow generic level identification. Furthermore, 103 of the 181 identified specimens are in just two genera, *Mangeroceras* and *Neoaganides*, each represented by one species. Thus, more than 70 percent of the ammonoid collection consists of two species and unidentifiable specimens. The remaining 78 specimens in the collection are referred to 15 genera and 14 species.

In 1954, Unklesbay summarized the distribution of Pennsylvanian cephalopods in North America. Since that time, numerous changes in ammonoid taxonomy have been proposed (Beghtel, 1962; Gordon, 1964; McCaleb, 1968; Nassichuk, 1975; and numerous other reports). In his report, Unklesbay indicated that 110 species of ammonoids were known from Pennsylvanian strata in North America. The number of specimens that comprises these 110 species is not known but undoubtedly would be in the thousands. By far, the majority of these species were from the Midcontinent region. Precise figures for the number of Pennsylvanian ammonoids collected from the Midcontinent are not available; however, some rough estimates can be calculated. The Wewoka Formation (upper Desmoinesian) in Oklahoma has produced more than 10,000 ammonoids. Available undescribed ammonoid collections at Ohio University, collected since 1978 from Desmoinesian through Virgilian strata in Texas, number more than 10,000 specimens. Additional Pennsylvanian ammonoid collections from Oklahoma (exclusive of the Wewoka Formation) and Arkansas easily exceed 10,000 specimens. Although most of these collections, totaling more than 30,000 specimens, have not been formally analyzed and described, the vast majority of the specimens are conspecific with previously described taxa (the 110 species summarized by Unklesbay) from the Midcontinent. By comparison, the 22 taxa represented by 181 identifiable specimens from Pennsylvanian strata in Ohio would appear to be a case of moderate diversity.

DISCUSSION

It is clear from the above figures that Midcontinent Pennsylvanian strata have produced far more ammonoids than the age-equivalent marine units in Ohio. Intensive collecting by Sturgeon and his colleagues has produced an excellent Pennsylvanian-age collection of 60,000+ invertebrate fossils. Yet relatively few of the more than 400 collecting localities have produced ammonoids. Sturgeon has recognized that a single ammonoid specimen might be recovered for every 15 to 25 collecting trips and that, when an ammonoid locality was discovered, intensive collecting of the exposure would perhaps yield a few tens of specimens at most. He further has noted that nautiloid cephalopods are much more common, and that specimens were recovered on almost every field trip. By contrast, in parts of the Midcontinent, examination of the Pennsylvanian strata by trained ammonoid collectors has revealed new ammonoid localities on most collecting trips. Some of these localities have produced 500 to 1,000 ammonoids in a single day's collecting.

The reasons for the drastic difference in the relative abundance of ammonoids is not completely clear. A general analysis by Boardman and others (1983) of many ammonoid-bearing exposures of Middle and Late Pennsylvanian age in the Midcontinent indicates the following conditions. In most exposures, the ammonoids are recovered from uncemented, concretion-bearing clay shales deposited in offshore marine conditions. Typically, the fauna is molluscan dominated. Less abundant fossil elements include representatives of other common invertebrate taxa such as trilobites, corals, and brachiopods. Thus, it appears that on the basis of faunal association, the salinities of the Pennsylvanian seas where the shales were deposited were in the normal range in relation to modern salinities. The shales are generally dark to medium gray and commonly contain plant petrifactions. In many cases a particular exposure yields juvenile and no adult ammonoids at the base of the section where the shales are darker gray, and more adult forms in the overlying lighter gray shales.

In Ohio, most of the ammonoids were recovered from dark- to medium-gray calcareous shales. Most of the ammonoid- bearing localities appear to be perhaps less molluscan dominated than the Midcontinent localities. The invertebrate fauna is generally quite diverse, although perhaps less so than those of the Midcontinent.

In the Midcontinent, sediments came from multiple sources. Most of the Pennsylvanian ammonoid localities in Texas, Oklahoma, and Kansas were on more-or-less stable platforms or shelves. Reef development and carbonate deposition were more restricted during the Pennsylvanian in these areas; where shallow-water limestones are present, relatively few ammonoids have been recovered. Depositional environments associated with deltas appear to transgress periodically across parts of these platforms and shelves during times of marine regression.

In Ohio, the Pennsylvanian stratigraphic succession is dominated by deltas which were filling a basin located between the Appalachian highlands to the southeast and the low- lying craton to the north and northwest. Marine deposition was relatively rare in early Pennsylvanian time; however, marine incursions took place with moderate frequency, especially during Allegheny and Conemaugh time and, with one exception (Skelley unit), terminated in mid-Conemaugh time.

These sweeping generalities imply that many Pennsylvanian ammonoid cephalopods preferred environments where shallow-water carbonates were not being deposited. Both the Midcontinent platforms and shelves, which have prolific ammonoid faunas, and the Ohio portion of the Appalachian Basin, which has relatively few ammonoids, were crossed or filled by delta-related sediments during regressions of the inland seas. Ammonoids are not common in delta-front environments in either region. We also suspect that sediments deposited during transgressions (“deeper water”) have markedly higher numbers and diversity of ammonoids in comparison to sediments deposited during regressive (“shallow water”) events. Additional environmental studies of both ammonoid- and non-ammonoid-bearing marine units are needed. That there were specific conditions that controlled ammonoid occurrences is apparent when Midcontinent Pennsylvanian localities are compared to Ohio localities of more-or-less equivalent age. These specific conditions remain to be identified and applied to the ammonoid record.

Chapter 2-3

OCCURRENCE AND BIOSTRATIGRAPHY OF OHIO AMMONOIDS

At this time, we cannot make precise biostratigraphic correlations of each ammonoid-bearing marine unit in Ohio with the abundant and diverse ammonoid faunas in the Midcontinent. This lack of correlation is due in part to the relatively few taxa recovered from Ohio strata. Furthermore, the ammonoid faunas from the Midcontinent need extensive re-evaluation. Generic identities and diagnoses for many Midcontinent ammonoids are well established; however, some genera are not well defined and are the subject of continuing controversy. Species-level identifications are in many cases impossible to determine from the published literature. However, probably the most important reason for the lack of precise biostratigraphic correlation is the abundance of relatively recently discovered, unanalyzed ammonoid-bearing localities in the Midcontinent. Many of these localities are from stratigraphic units from which ammonoids have not been previously known. Also, with better understanding of the more complete stratigraphic succession in the Midcontinent, it will be possible to arrive at far more detailed phyletic and biostratigraphic conclusions as these more recently discovered Midcontinent ammonoids are analyzed and the new data become integrated with the described faunas. When the studies currently underway are more complete, it will be possible to more meaningfully relate the ammonoid-bearing marine units in Ohio to the more complete Midcontinent succession.

The Pennsylvanian and Permian strata in Ohio traditionally have been divided into five groups, which are, from oldest to youngest: Pottsville, Allegheny, Conemaugh, Monongahela, and Dunkard. Marine units are rare to absent in the Monongahela and Dunkard Groups, and these groups have not yielded ammonoid specimens (table 2-1). All five groups have been subdivided into numerous named beds, which are here referred to informally as units.

POTTSVILLE GROUP

Ammonoids from the Pottsville Group have been recovered from the Lowellville (Poverty Run) and Lower Mercer marine units, which are positioned approximately midway in the Pottsville stratigraphic succession. These marine units have yielded the following genera and species of ammonoids.

- Lower Mercer unit:
  - *Gastrioceras* sp.
  - ?*Paralegoceras* sp.
  - unidentified ammonoids
- Lowellville (Poverty Run) unit:
  - *Dimorphoceratoides campbellae* Furnish & Knapp
  - *Gastrioceras* sp.
  - *Mangeroceras* cf. *M. canfieldense* Sturgeon, Windle, Mapes & Hoare
  - *Phaneroceras* sp.
  - unidentified ammonoids

In North America, *Gastrioceras* (*sensu lato*) ranges from Morrowan to perhaps as late as middle Desmoinesian time. According to Nassichuk (1975), various species of this genus seem to be diagnostic for certain stages. But, because we are uncertain of the species that occur in Ohio, this taxon does not lend itself to any detailed biostratigraphic interpretation. *Phaneroceras* probably ranges through the same time interval as *Gastrioceras*, and therefore is also not a precise biostratigraphic indicator. The single specimen of *Mangeroceras* cf. *M. canfieldense* from the Lowellville (Poverty Run) unit is a piece of test that bears a resemblance to that taxon. This specimen has been placed in *Mangeroceras* with strong reservation and it is possible that the specimen belongs to another genus. Thus, the occurrence of this genus is very questionable, and as such, we do not consider it biostratigraphically significant at this time. *Dimorphoceratoides campbellae* is the most restricted taxon that occurs in the Pottsville Group. Furnish and Knapp (1966) described this taxon from the Breathitt Formation (Pottsville equivalent) in Kentucky and indicated that the Breathitt is equivalent to strata equivalent to the Bloyd Formation (upper Morrowan) in Arkansas and Oklahoma. In addition, they indicated that an undescribed specimen from the Winslow Formation (Atokan) in Arkansas may be congeneric. Saunders, Manger, and Gordon (1977, table 3) indicated that the specimen is from the Trace Creek Shale Member of the Bloyd Formation.

On the basis of the above information, we would correlate the Lowellville (Poverty Run) unit to the Upper Morrowan Series-Upper Bloyd Stage of Oklahoma and Arkansas. According to Saunders and others (1977), *Dimorphoceratoides* is associated with the ammonoid fauna of the *Diaboloceras neumeieri* Zone. Both Saunders and others (1977) and Nassichuk (1975) have suggested that *Rodiezmoceras bisati* Wagner-Gentis from the Westphalian B in northwestern Spain is probably congeneric with *Diaboloceras*. Thus, on the basis of a single ammonoid taxon, it appears that the Lowellville (Poverty Run) unit belongs in the *Diaboloceras neumeieri* Zone, which in turn is probably equivalent to part of the Westphalian B succession in western Europe.

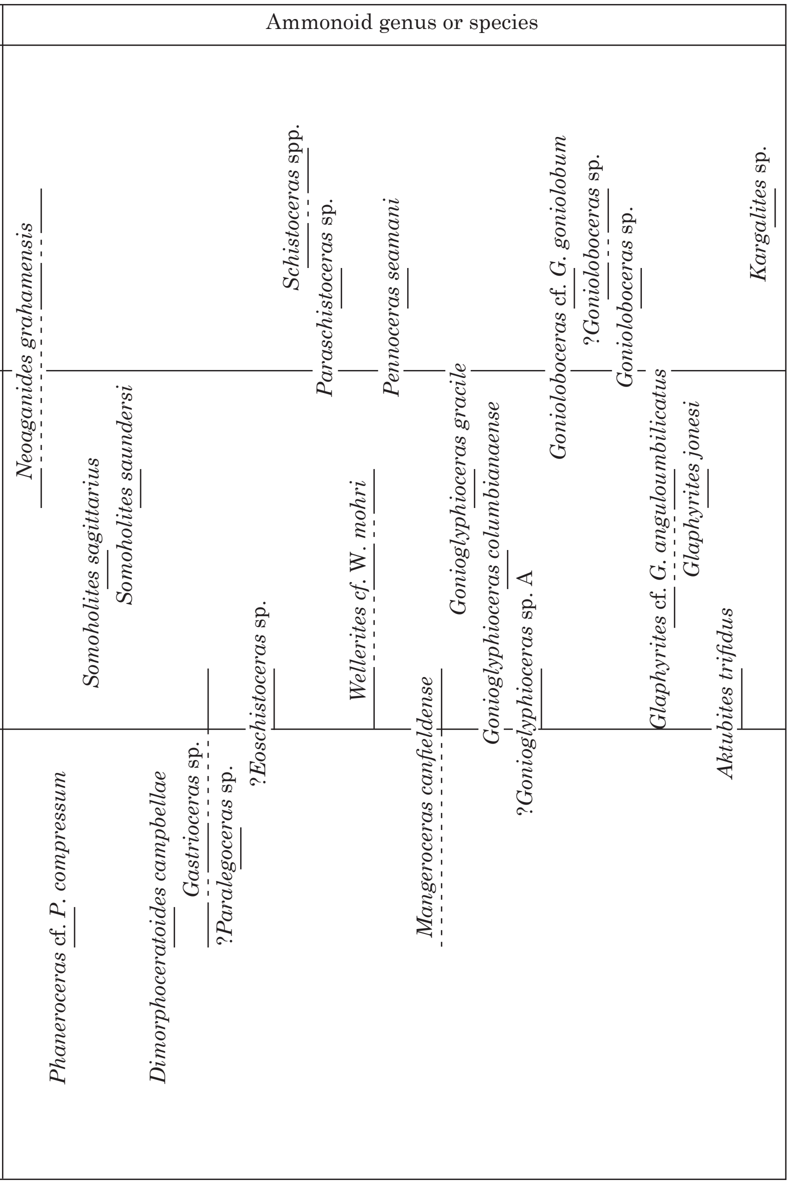
The Lower Mercer unit overlies the Lowellville (Poverty Run) unit and is therefore younger; however, both of the ammonoid taxa (*Gastrioceras* and *Paralegoceras*) recovered from this member are long ranging.

ALLEGHENY GROUP

Ammonoids from the Allegheny Group have been recovered from four units ranging from the lower to lower-upper

TABLE 2-1.—Stratigraphic distribution[1] of Pennsylvanian ammonoid cephalopods in Ohio

Group	Marine/brackish-water units[2]
Conemaugh	Skelley limestone and shale
	Gaysport limestone and shale
	Ames limestone and shale
	Portersville shale and limestone
	Cambridge limestone and shale
	Brush Creek limestone and shale
	Mason shale
Allegheny	unnamed shale
	Dorr Run shale
	Washingtonville shale
	Tuscarawas shale
	Columbiana shale and limestone
	Vanport limestone, flint, and shale
	Zaleski flint, limestone, and shale
	Putnam Hill limestone and shale
Pottsville	Upper Mercer limestone, flint, and shale
	Sand Block ironstone
	Lower Mercer limestone and shale
	Boggs limestone, flint, and shale
	Lowellville (Poverty Run) limestone and shale
	Bear Run shale
	Quakertown shale
	Anthony shale
	Sharon ironstone and shale
	Harrison ironstone



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[1] Dashed lines indicate inferred distribution.

[2] The stratigraphic names listed in this table are the traditional/historical names used for the Pennsylvanian units in Ohio.

portion of the group. They are, in ascending order, the Putnam Hill, Vanport, Columbiana, and Washingtonville. The marine strata of the Allegheny Group have yielded the greatest diversity of ammonoids of all of the groups. The following ammonoid genera and species have been identified from these units.

Washingtonville unit:
- *Glaphyrites* cf. *G. anguloumbilicatus* Plummer & Scott
- *Glaphyrites jonesi* Miller & Owen
- *Gonioglyphioceras gracile* (Girty)
- *Neoaganides grahamensis* Plummer & Scott
- *Somoholites saundersi* n. sp.
- *Wellerites* cf. *W. mohri* Plummer & Scott

Columbiana unit:
- *Gonioglyphioceras columbianaense* n. sp.
- *Somoholites sagittarius* Saunders
- *Wellerites* cf. *W. mohri*

Vanport unit:
- unidentified ammonoids

Putnam Hill unit:
- *Aktubites trifidus* Ruzhencev
- ?*Eoschistoceras* sp.
- *Gastrioceras* sp.
- *Glaphyrites* cf. *G. anguloumbilicatus*
- *Gonioglyphioceras* sp. A
- *Mangeroceras canfieldense* Sturgeon, Windle, Mapes & Hoare
- *Wellerites* cf. *W. mohri*

Of the seven genera of ammonoids recovered from the Putnam Hill unit, several species are unique to the Appalachian Basin. *Mangeroceras canfieldense* is the only new genus present in the Ohio collections. As presently known, this taxon has only been recovered from the Putnam Hill unit, excluding the questionable occurrence from the Lowellville (Poverty Run) unit previously mentioned; therefore, this genus is considered endemic to the Appalachian Basin. One new species is present in the collection; poor preservation and the limited number of specimens precludes the naming of this taxon, which is referred to herein as ?*Gonioglyphioceras* sp. A. This taxon appears to be transitional between the Atokan-lower Desmoinesian genus *Gonioloboceratoides* and the Desmoinesian genus *Gonioglyphioceras*. Both *Wellerites* and *Gonioglyphioceras* are considered to be Desmoinesian index fossils for the Midcontinent stratigraphic succession. *Eoschistoceras* also is probably restricted to Desmoinesian strata. *Gastrioceras* (*sensu lato*) is known to range from Morrowan to perhaps as late as middle Desmoinesian. Thus, all of these taxa clearly indicate a Desmoinesian age for the Putnam Hill unit. On the basis of the primitive shape of the conch of ?*Gonioglyphioceras* sp. A, we suggest an early (but perhaps not earliest) Desmoinesian age for the Putnam Hill unit. A more precise correlation with Midcontinent strata cannot be made at this time.

Aktubites trifidus was first known from middle Carboniferous units in the Soviet Union. The recognition of this genus in the Putnam Hill ammonoid fauna is one of the first known occurrences of the genus in North America. Ruzhencev and Bogoslovskaya (1978) suggested that *Aktubites* arose in the junction of the Moscovian? (≃ Desmoinesian) and Zhigulian (≃ Missourian) Stages. On the basis of the ammonoids associated with *A. trifidus* in Ohio, we suggest that the Parashumarditidae lineage began early in the Desmoinesian or perhaps as early as Atokan time.

At the present time, only a single ammonoid specimen of *Glaphyrites*, which we have tentatively referred to *Glaphyrites* cf. *G. anguloumbilicatus*, has been recovered from the Putnam Hill unit. Because of the extreme taxonomic confusion regarding this and similar-appearing genera and the plethora of species assigned to this taxon, a meaningful statement regarding the biostratigraphic significance of this specimen cannot be made at this time. The scarcity of this genus in the Appalachian Basin is surprising, as Midcontinent strata of approximately the same age have yielded thousands of specimens.

Of the three distinct genera from the Columbiana unit, two, *Gonioglyphioceras* and *Wellerites*, are restricted to Desmoinesian strata in the Midcontinent. *Gonioglyphioceras columbianaense* exhibits relatively primitive sutural characteristics as compared to Midcontinent species assignable to *Gonioglyphioceras*. For this reason, we consider it likely that the ammonoid fauna from the Columbiana unit is older than the ammonoid fauna from the Marmaton Group in Oklahoma. A more definitive correlation cannot be made at this time. *Somoholites sagittarius* is less diagnostic as a biostratigraphic indicator because relatively few Pennsylvanian representatives of the genus have been described; however, the lobes and saddles of *S. sagittarius* are more inflated than those of the older *S. merriami* from Atokan strata in Oregon and Oklahoma (Saunders, 1971). When better known, this genus may prove to be a good biostratigraphic indicator.

Of the five genera and six species of ammonoids in the Washingtonville unit, four taxa—*Glaphyrites* cf. *G. anguloumbilicatus*, *G. jonesi*, *Neoaganides grahamensis*, and *Somoholites saundersi*—are not biostratigraphically diagnostic at this time because they are long ranging and there is disagreement about their taxonomic composition and phylogeny. However, two of the Washingtonville taxa, *Gonioglyphioceras gracile* and *Wellerites* cf. *W. mohri*, are excellent Desmoinesian index fossils. In the Midcontinent, *Gonioglyphioceras gracile* appears to be confined to Marmaton strata in Oklahoma and equivalent strata (upper Desmoinesian-Strawn) in Texas. Thus, the Washingtonville unit may be equivalent to part of the upper Desmoinesian in the Midcontinent.

All of the ammonoid-bearing units in the Allegheny Group are Desmoinesian in age. On the basis of the evolutionary trends exhibited by *Gonioglyphioceras*, it appears that most of the Allegheny marine units range in age from perhaps early to late Desmoinesian. Additional study is necessary. The discovery of additional ammonoids from the Allegheny Group in Ohio and the lower and middle Desmoinesian marine units in the Midcontinent would help.

CONEMAUGH GROUP

The Conemaugh Group has yielded ammonoids from four marine units in the lower and middle part of the group. They are, in ascending order, the Brush Creek, Cambridge, Portersville, and Ames. The following ammonoid genera and species have been identified from the Conemaugh Group.

Ames unit:
  Schistoceras sp.
Portersville unit:
  Gonioloboceras sp.
  Kargalites sp.
  Neoaganides grahamensis
Cambridge unit:
  Schistoceras sp.
Brush Creek unit:
  Gonioloboceras cf. *G. goniolobum* (Meek)
  Gonioloboceras sp.
  ?*Gonioloboceras* sp.
  Neoaganides grahamensis
  Paraschistoceras sp.
  Pennoceras seamani Miller & Unklesbay

Two of the four genera of ammonoids from the Brush Creek unit, *Gonioloboceras* and *Neoaganides*, are long-ranging taxa that are known to occur in upper Desmoinesian through Virgilian strata in the Midcontinent. *Paraschistoceras* is a poorly understood taxon that appears to range from Missourian to perhaps Virgilian. *Pennoceras seamani* is an endemic taxon presently known only from the Brush Creek marine unit in the Appalachian Basin (specifically Ohio and Pennsylvania).

Correlation of the Brush Creek unit with strata of equivalent age in the Midcontinent on the basis of ammonoids is impossible at this time, as phylogenetic lineages have not been established. Indeed, several of these genera, specifically *Gonioloboceras*, *Paraschistoceras*, and perhaps *Neoaganides*, have been subjected to extensive, and in our opinion perhaps excessive, lumping at the species level, which hinders detailed biostratigraphic correlation.

The Brush Creek unit is considered to be equivalent to Missourian strata in the Midcontinent. This conclusion is in part based on the presence of the fusulinid *Triticites ohioense* reported by Thompson (1936); this taxon is considered to be a good index fossil for Upper Pennsylvanian strata (Thompson, 1964).

The Cambridge unit has yielded one ammonoid genus, *Schistoceras*. Some confusion exists concerning the taxonomic range of this genus; however, representatives of this genus have been reported from Upper Pennsylvanian (Missourian and Virgilian) strata. Until details regarding the various species can be determined, no precise correlation of this Ohio marine unit with the Midcontinent stratigraphic succession can be made.

Of the three ammonoid genera in the Portersville unit, two, *Gonioloboceras* and *Neoaganides*, are considered to be long ranging. The remaining taxon has been assigned to *Kargalites* with reservation because of the lack of an external suture and the confusion in the literature concerning the generic composition of the family. Thus, all three taxa contribute little toward biostratigraphic correlation at this time.

The Ames unit yielded a single specimen of *Schistoceras*. The same reservations given for *Schistoceras* recovered from the Cambridge unit apply to this occurrence.

In summary, the ammonoids recovered from the Conemaugh Group are relatively undiagnostic biostratigraphically at this time. As detailed systematic treatment of the more complete ammonoid faunas from the Midcontinent are concluded, it will almost certainly be possible to use these Ohio ammonoids for more precise biostratigraphic correlations.

Chapter 2-4

SYSTEMATIC PALEONTOLOGY OF OHIO AMMONOIDS

Genus *Neoaganides* Plummer & Scott, 1937

Type species: *Neoaganides grahamensis* Plummer & Scott, 1937, p. 350-351, pl. 40, figs. 4-9, text-fig. 72; OD

Diagnosis.—Pseudohaloritid having rounded "goniatitic" lobes. Conch small (D = 10 to 20 mm) and varying from subdiscoidal to subglobular. Sculpture formed by growth lines outlining well-developed hyponomic sinus and shallow ocular sinus. Mature peristome simple, unconstricted, and without pronounced lappets. Siphuncle ventrad of dorsal septal flexure and subcentral at maturity.

Remarks.—Frest, Glenister, and Furnish (1981) have provided an up-to-date summary of this taxon and its morphological features. They place *Neoaganides* in the subfamily Shouchangoceratinae Zhao & Zheng, 1977, which was originally established as a family. Frest and others (1981) included the following genera within this subfamily:

Neoaganides Plummer & Scott, 1937
Sosioceras Frest, Glenister & Furnish, 1981
Shouchangoceras Zhao & Zheng, 1977
Shangraoceras Zhao & Zheng, 1977
Zangzhites Zhao & Zheng, 1977
Elephantoceras Zhao & Zheng, 1977
Erinoceras Zhao & Zheng, 1977

Of these taxa, only *Neoaganides* is found in the Pennsylvanian strata of North America. Frest and others (1981) have placed the following species in the genus *Neoaganides*:

N. grahamensis Plummer & Scott, 1937
N. multiseptatus (Zhao, 1940)
N. nesenensis Frest, Glenister & Furnish, 1981
N. paulus Zhao, Liang & Zheng, 1978
N. rectilobatus Ruzhencev, 1950
N. tabantalensis Ruzhencev, 1952
Neoaganides sp. 1
Neoaganides sp. 2

The taxon most similar to *Neoaganides* in North America has been considered to be *Maximites* Miller & Furnish, 1957. However, the extensive study of the cheiloceratacean ammonoids by Frest and others (1981) indicates these taxa arose at different times from a prionoceratid ancestor and that reassigning *Neoaganides* to the family Pseudohaloritidae better reflects the phyletic relationship. Some of the differences they note between these two genera are as follows: (1) at maturity, *Maximites* has a divided ventral lobe, whereas *Neoaganides* has an undivided ventral lobe; (2) *Maximites* has a smaller conch than *Neoaganides* when diameters are compared at the nepionic constriction; (3) *Maximites* has a deep, transverse nepionic constriction, whereas *Neoaganides* has a shallow nepionic constriction and a conspicuous ventral sinus; and (4) the siphuncle in *Maximites* becomes ventral and marginal at maturity, whereas in *Neoaganides*, the siphuncle remains subventral.

Geologic and geographic range.—*Neoaganides* has been recovered from Upper Pennsylvanian to Upper Permian strata. Of the eight forms recognized by Frest and others (1981), only *N. grahamensis* has been recovered from Upper Pennsylvanian strata in the Midcontinent (Iowa, Kansas, Missouri, Oklahoma, and Texas). The occurrence of this genus from units of similar stratigraphic level in Ohio indicates a wider paleobiogeographic distribution than has been previously recognized. However, the taxon is still endemic to North America. Other species of *Neoaganides* have been recovered from Pennsylvanian and Permian strata in the United States, the former Soviet Union, Iran, and China.

Neoaganides grahamensis Plummer & Scott, 1937
Pl. 2-1, figs. 2, 5-7, 9

Neoaganides grahamensis Plummer & Scott, 1937, p. 350-351, pl. 40, figs. 4-9, text-fig. 72; Gordon, 1964, p. 165; Windle, 1970, p. 114-116, pl. 2, figs. 1, 2.
Imitoceras grahamense Miller & Owen, 1939, p. 146-147; Miller and Downs, 1950, p. 193-194, pl. 32, figs. 1-4, text-fig. 2; Tasch, 1953, p. 447-448, pl. 50, figs. 5, 6; Miller, Furnish & Schindewolf, 1957, p. L49-L50, figs. 5, 6; Unklesbay, 1962, p. 55-56; Frest, Glenister & Furnish, 1981, p. 19-22, pl. 2, figs. 19-22, pl. 3, figs. 1-14, text-figs. 2D, 6E-H, 14D, table 3.
Imitoceras? sp. Sturgeon & Miller, 1948, p. 79.

Diagnosis.—*Neoaganides* having a mature conch reaching about 10 mm in diameter; conch smooth in early juvenile stages, mature body chamber marked by falcations (sickle-shaped ribs); at maturity, aperture forming well-developed hyponomic and ocular sinuses. Suture having relatively narrow ventral and lateral lobes; sutural formula at maturity = VLU:ID.

Material.—*Neoaganides grahamensis* is represented in the Ohio collections by 55 specimens. Many of the specimens are well preserved and some retain traces of aragonitic test; others are juveniles or crushed.

Description.—Conch subdiscoidal at maturity, more globular in juvenile stages. Conch dimensions and proportions given in table 2-2.Umbilicus of mature conchs slightly open on internal molds but closed on testiferous specimens; umbilicus of juvenile conchs more open. Mature modifications including slight flattening of venter on some specimens; others having a rounded venter. Falcations present on lateral and umbilical areas of body chambers of some specimens. Aperture exhibiting a well-developed hyponomic sinus and shallow ocular sinus; bluntly rounded salient present on ventrolateral portion of mature conch aperture; several specimens (OSU 30783, 30784, 30785) having a black rim around aperture at maturity. Growth lines apparently only

TABLE 2-2.—*Conch measurements and ratios*[1] *of* Neoaganides grahamensis

Specimen	D (mm)	Umax (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
OSU 13954 (hypotype)	3.2	0.4	2.0	2.1	0.13	0.63	0.66	0.95
OSU 13955 (hypotype)	4.3	0.4	2.6	2.7	0.09	0.60	0.63	0.96
OSU 30782 (hypotype)	8.9	1.1	5.1	3.5	0.12	0.57	0.39	1.46
OSU 30783 (hypotype)	7.1	1.7	4.5	3.5	0.24	0.63	0.49	1.29
OSU 30784 (hypotype)	7.1	1.0	4.0	3.3	0.14	0.56	0.46	1.21
OSU 30785 (hypotype)	4.2	1.0	2.5	2.3	0.24	0.59	0.55	1.09
OSU 30786 (hypotype)	4.6	0.5	2.6	2.5	0.11	0.57	0.54	1.04
OSU 30787 (hypotype)	4.8	1.0	2.9	3.0	0.21	0.60	0.63	0.97
OSU 30788 (hypotype)	6.9	1.0	3.8[2]	3.5	0.14	0.55	0.51	1.09

[1] The measurement and ratio abbreviations for tables 2-2 to 2-10 are explained on page 197. Umbilical measurements are variable owing to the presence or absence of shell; only Umax can be determined because of the umbilicus.

[2] Estimate.

ornament in most specimens, although internal mold of one specimen (OSU 30841) has well-developed longitudinal lirae on body chamber. Only one specimen (OSU 13954) showing a growth constriction, occurring at a conch diameter of 2.5 mm; constriction follows form of growth lines and is probably the nepionic constriction. Suture pattern on most Ohio specimens covered by body chamber or destroyed by crushing, juveniles having a slightly divided, relatively narrow ventral lobe and a wider more rounded lateral lobe; mature specimens exhibiting septal approximation showing an undivided U-shaped ventral lobe having nearly parallel sides and a wide, rounded lateral lobe (figs. 2-3A, 2-3B). Several specimens showing some degree of asymmetry in placement of ventral lobe on venter and on tip of lateral lobe.

Remarks.—Neoaganides grahamensis is most closely similar to *N. tabantalensis* Ruzhencev; however the suture on *N. tabantalensis* has a much narrower lateral lobe than *N. grahamensis*. In essentially all details, the Ohio specimens conform to the conch form and sutural descriptions provided by Frest and others (1981) on the Midcontinent specimens. The size of some of the smaller Ohio specimens prohibits distinguishing *Neoaganides* from *Maximites*; these specimens are placed in *Neoaganides grahamensis* with reservation.

The blackened rim on the aperture of some mature *N. grahamensis* specimens from Ohio is a previously unreported characteristic of this species. We are aware of only two similar reports on Pennsylvanian ammonoids, both by Nassichuk (1967, 1975), who described a black layer associated with *Clistoceras*, a lower Middle Pennsylvanian ammonoid recovered from the Canadian Arctic. In addition to reporting this morphological feature, he commented on a possible homologous relationship to the black layer found on *Nautilus*.

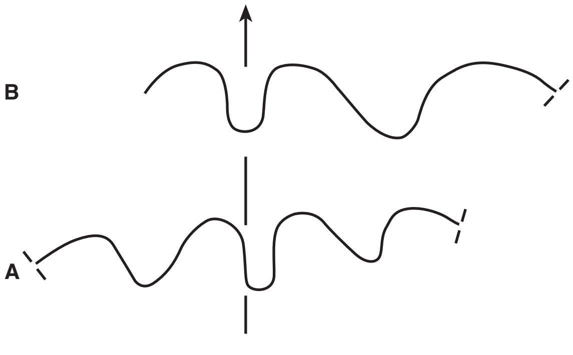

FIGURE 2-3.—Sutural outlines of hypotypes of *Neoaganides grahamensis* Plummer & Scott. Brush Creek unit, loc. Ale-18.

A, at estimated diameter of 3.5 mm (maximum diameter of conch = 4.8 mm). OSU 30787. Note that suture is markedly asymmetrical in that the ventral lobe is not centrally located on the venter and that the lateral lobes are distinctly different.

B, at estimated diameter of 4.5 mm (maximum diameter of conch = 6.9 mm). OSU 30788.

Nautilus characteristically deposits a black layer around the inside lip of the aperture of the body chamber at maturity (Collins and others, 1978, and others). Because several specimens of *Neoaganides grahamensis* from Ohio (OSU 30783, 30784, 30785) retain traces of what is almost certainly aragonitic shell in association with a blackened apertural lip, it seems probable that a close relationship with *Nautilus* exists in regard to the deposition of the black material around the lip of the shell at maturity. It should be noted that specimen OSU 30785 is approximately one-half the diameter of the other specimens that show this characteristic. Thus, it is possible that microconch-macroconch sexual dimorphism is present within this taxon if the black layer truly represents maturity.

Occurrence.—57 specimens total; Brush Creek unit: 10 specimens from loc. Ale-18, 21 specimens from loc. Ale-35, 3 specimens from loc. MUuc-2; Portersville unit: 1 specimen from loc. Gwe-2; Washingtonville unit: 20 specimens from loc. Cc-7 (18 with reservations owing to specimens being in early stages of development); 2 specimens from loc. CAr-2.

Repository.—Hypotypes OSU 13954, 13955, 19605, 30701, 30702, 30782 to 30789, 30838, 30841.

Genus *Phaneroceras* Plummer & Scott, 1937

Type species: *Gastrioceras compressum* Hyatt, 1891, p. 355-356, text-figs. 57-59; OD

Diagnosis.—Pseudoparalegoceritid having umbilical lobe of suture located between umbilical seam and umbilical shoulder. Sutural formula = (V_1V_1) LU:ID.

Remarks.—Phaneroceras has had a relatively complex taxonomic history in that there has been considerable difference of opinion regarding the validity of this genus and *Pseudoparalegoceras* Miller, 1934. The closely related genus *Pseudoparalegoceras* differs in sutural configuration from *Phaneroceras* by having the umbilical lobe outside the umbilical shoulder on the umbilical lateral region of the conch. This difference is, according to Nassichuk (1975), sufficient to separate the two genera; however, he cautions that because the umbilical lobe can migrate during ontogeny, only relatively mature specimens can be identified with confidence. We agree with Nassichuk that the position of the U element is a generic-level characteristic, and thus *Phaneroceras* is distinguishable from *Pseudoparalegoceras*. In regard to the genus *Eoparalegoceras* Delépine, 1939, which has an umbilical lobe at or very near the umbilical shoulder, it becomes a matter of taxonomic opinion as to whether intermediate umbilical lobe positions should be recognized at the generic level. Nassichuk (1975) prefers to see this genus suppressed, whereas Ruzhencev and Bogoslovskaya (1978) retain it as a separate generic identity. We suspect that there is probably a gradation of umbilical lobe positions between *Phaneroceras* and *Pseudoparalegoceras*; to resolve this issue, detailed studies must be undertaken. If such study revealed a gradation, we would recommend that all of the taxa involved be assigned to *Pseudoparalegoceras*, which has priority, and that subgenera be used to identify the evolutionary development based on the position of the umbilical lobe relative to the umbilical shoulder. Gordon (1964) initiated this usage.

Nassichuk (1975, p. 111, 112) provides a detailed summary of the eight recognized species assignable to *Phaneroceras* and their stratigraphic occurrences and the five species assignable to *Pseudoparalegoceras*. Because all of these taxa are eight lobed, minor variations in suture pattern and conch proportions are probably the most significant species-level characteristics. In addition, Plummer and Scott (1937) and Gordon (1964) indicate that the number of constrictions per volution may be important species-level characteristics. However, Nassichuk (1975) states that his specimens of *Phaneroceras lenticulare* show a variable number of constrictions within the species. We recommend the use of extreme caution in utilizing the number of constrictions as a species-level characteristic.

Geologic and geographic range.—Phaneroceras has been recovered from middle Morrowan through Desmoinesian strata in North America (Canadian Arctic, United States, and Mexico), South America (Peru), North Africa (Morocco), Japan, China, and the former Soviet Union.

Phaneroceras cf. *P. compressum* (Hyatt, 1891)
Pl. 2-5, fig. 6

Gastrioceras compressum Hyatt, 1891, p. 355-356, text-figs. 57-59; Smith, 1903, p. 86, pl. 9, figs. 1-3.

Phaneroceras compressum Plummer & Scott, 1937, p. 191-193, pl. 9, figs. 4, 5, 7-10 (non pl. 9, fig. 6, pl. 11, fig. 13); Nassichuk, 1975, p. 114-115, pl. 11, fig. 3.

Pseudoparalegoceras compressum Miller & Furnish, 1940, text-fig. 3B; Miller, Furnish & Schindewolf, 1957, fig. 85; Murray, Furnish & Carrillo Bravo, 1960, p. 736, text-fig. 5C; Ruzhencev, 1962, p. 382, text-fig. 150a, pl. 24, fig. 1; Unklesbay, 1962, p. 91-93, pl. 15, fig. 10; McCaleb, 1963, p. 876-877, text-fig. 6A, pl. 112, figs. 1, 2, 6; 1968, p. 57-59, text-fig. 17A, B, pl. 4, figs. 5-7, pl. 12, fig. 7; Nishida, 1971, p. 10-12, pl. 4, figs. 1-3, pl. 5, figs. 1, 2.

Pseudoparalegoceras (Phaneroceras) compressum Gordon, 1964, p. 264-265, text-fig. 83A, B, pl. 29, figs. 1-4, 18-20.

Diagnosis.—Phaneroceras having relatively large umbilicus in relation to conch diameter (U/D = 0.4); umbilical lobe of suture approximately centered between umbilical seam and umbilical shoulder.

Material.—Phaneroceras cf. *P. compressum* is represented in the Ohio collections by two specimens. The larger specimen (OSU 13327) is laterally flattened; the other specimen (OSU 30815) is a nontestiferous pyritized fragment of a phragmocone.

Description.—Larger specimen (OSU 13327) having crushed diameter of 89.0 mm and maximum umbilical diameter of 42.0 mm, U/D = 0.47; traces of test present but no growth lines or ornament preserved beyond pronounced ridge caused by shell thickening on umbilical shoulder. Smaller specimen (OSU 30815) having following approximate measurements and ratios: D = 50.0 mm, H = 15.0 mm, W = 20.0 mm, Umax = 22.0 mm, Umax/D = 0.44, H/D = 0.30, W/D = 0.40, W/H = 1.33. Neither specimen exhibiting a complete suture; both specimens having exposed umbilical lobes located asymmetrically between umbilical shoulder and seam. Other sutural details indeterminable.

Remarks.—These two specimens are placed in *Phaneroceras* cf. *P. compressum* with reservation as little in the way of sutural detail is preserved. However, the conch proportions are generally similar to those reported by McCaleb (1968, table 7). Because of the general conch similarities and the position of the umbilical lobe of the suture, the tentative assignment of these specimens to *Phaneroceras* cf. *P. compressum* seems warranted. It should be noted that an adequate comparison with other taxa assigned to *Phaneroceras* cannot be accomplished because of the overall poor preservation of the two specimens.

Occurrence.—2 specimens; Lowellville (Poverty Run) unit: loc. Tfr-1.

Repository.—OSU 13327, 30815.

Genus *Somoholites* Ruzhencev, 1938

Type species: *Gastrioceras beluense* Haniel, 1915, p. 54-56, pl. 48, fig. 1a-c; OD

Diagnosis.—Conch generally evolute and wide, having widely rounded to flattened venter and conspicuous umbilical shoulders. Ornament transverse or a combination of longitudinal and transverse lirae. Suture characterized by moderate to strong inflation of internal and external lobes, saddles broadly rounded. Sutural formula = (V_1V_1) LU:ID.

Remarks.—This genus and indeed all of the genera assigned to this family have been subject to considerable debate as to generic-level diagnostic characteristics. Initially, the majority of the work on *Somoholites* was done by Ruzhencev (1936, 1938, 1950, 1951, 1956a, 1956b). Because of the similarity of *Somoholites* to *Eoasianites*, *Syngastrioceras*, *Glaphyrites*, and other taxa, Miller and others (1957) indicated these taxa were junior synonyms of *Eoasianites*. Other workers (Beghtel, 1962; Kullmann, 1962; Wagner- Gentis, 1963; Gordon, 1964) have followed Miller and others (1957) in assigning *Somoholites* to either *Eoasianites* or *Glaphyrites*.

In 1971, Saunders made an intensive study of the available North American specimens of *Somoholites* and concluded that the genus was valid. Nassichuk (1975) and Ruzhencev and Bogoslovskaya (1978) also support the concept of *Somoholites*. However, neither Saunders nor Ruzhencev and Bogoslovskaya are in agreement on the morphological characteristics that define *Somoholites* or on the genera that belong in the family Somoholitidae. Undoubtedly, additional collections of specimens of the genera that have been assigned to the Somoholitidae are needed so that the family can be extensively restudied to correctly determine the generic phylogenies. In this report we accept the concept of *Somoholites*, *sensu* Saunders (1971). We strongly suspect that the presence or absence of longitudinal lirae, as indicated by Ruzhencev and Bogoslovoskaya (1978), are important specific or perhaps subgeneric morphological characteristics and are not, in this case, generic-level criteria. Both Nassichuk (1975) and Ruzhencev and Bogoslovskaya (1978) have reservations concerning the occurrence of this genus in Mississippian strata as reported by Saunders in 1971. Because study of these specimens is beyond the scope of this report, we cannot resolve this problem. However, examination of newly discovered specimens and the descriptions provided by Saunders (1971) indicate this Late Mississippian material is not conspecific with the Ohio specimens.

Geologic and geographic range.—Saunders (1971) indicates the geologic range for *Somoholites* as upper Chesterian (Upper Mississippian) to upper Wolfcampian (Lower Permian). Mississippian species occur in the United States (Oklahoma, Arkansas, Nevada), Spain, and Algeria. Pennsylvanian specimens occur in the United States (Oklahoma, Arkansas, Oregon, Ohio) and in the southern Urals in the former Soviet Union; Nassichuk (1975) also reported the occurrence of the genus in the Canadian Arctic. Permian species have been reported from the former Soviet Union, Timor, and the Canadian Arctic.

Somoholites sagittarius Saunders, 1971
Pl. 2-6, figs.1-3

Eoasianites cf. *E. globulosus* (Meek & Worthen, 1860); Miller & Sturgeon, 1946, p. 385-386, pl. 56, figs. 1-3, text-fig. 1; Sturgeon & Miller, 1948, p. 80.

Somoholites sagittarius Saunders, 1971, p. 110-111, pl. 23, figs. 10, 13, 14, text-fig. 5c (*non* text-fig. 5b).

Diagnosis.—A species of *Somoholites* characterized by sutural configuration having inflated ventrolateral saddle in comparison to inflated lateral lobe, distinct flexure in umbilical saddle of suture at position of umbilical shoulder, and moderately asymmetrical and inflated dorsolateral lobe.

Material.—Somoholites sagittarius is represented in the Ohio collections by two specimens. Both specimens are non-testiferous internal molds that exhibit fair preservation of the sutural pattern.

Description.—Saunders (1971, p. 110-111) has described both of the known Ohio specimens. His descriptions are essentially complete, and only minor details can be added to his description. Conch proportions and ratios are given in table 2-3. The suture on the paratype (OSU 30816) has recurved tips on the prongs of the ventral lobe (fig. 2-5B), but this feature is lacking on the holotype (OSU 18734, figs. 2-4A, 2-4B).

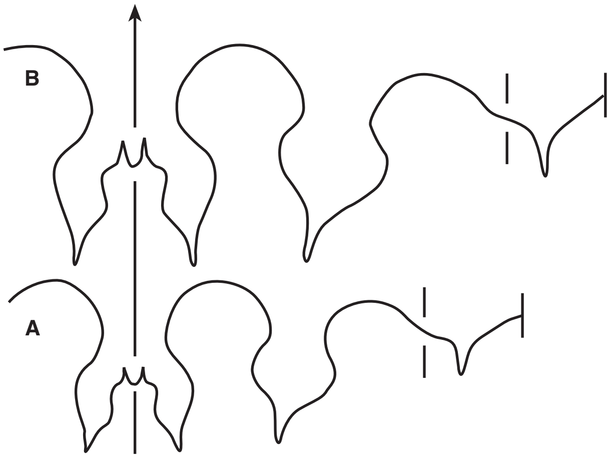

FIGURE 2-4.—Sutural outlines of holotype of *Somoholites sagittarius* Saunders. Columbiana unit, loc. Cs-7; OSU 18736.
A, at estimated diameter of 27 mm.
B, at estimated diameter of 22 mm.

Remarks.—Saunders (1971) and Nassichuk (1975) provide adequate comparisons to all other known species of *Somoholites* to distinguish *S. sagittarius* as a distinct species. *Somoholites sagittarius* differs from *S. saundersi* n. sp. (see below) in having a greater constriction of the lateral lobe, a more pronounced flexure in the umbilical saddle at the umbilical shoulder, and a less inflated dorsolateral lobe.

The sutural differences seen in the tips of the prongs of the

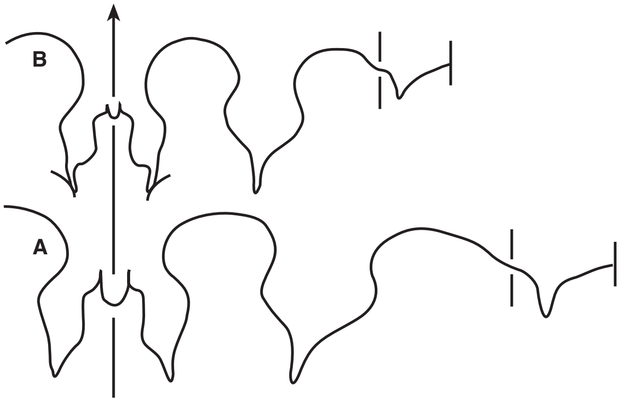

FIGURE 2-5.—Sutural outlines of *Somoholites saundersi* n. sp. and *S. sagittarius* Saunders.
A, holotype of *S. saundersi* at diameter of 20.3 mm. Washingtonville unit, loc. CAr-2; OSU 30805.
B, paratype of *S. sagittarius* at estimated diameter of 34.0 mm. Columbiana unit, loc. Cs-16; OSU 30816. Note recurved tips of prongs of ventral lobe caused by septal crowding.

TABLE 2-3.—*Conch measurements and ratios of* Somoholites sagittarius *and* S. saundersi

Specimen	D (mm)	Umax (mm)	Umin (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
S. sagittarius									
OSU 18736 (holotype)	27.9	17.0	12.7	6.5	20.3[1]	0.61	0.23	0.73	0.32
OSU 30816 (paratype)	34.0[1]	20.0[1]		6.9	23.0[1]	0.59	0.20	0.68	0.30
S. saundersi									
OSU 30805 (holotype)	22.1	12.9[1]	8.7	6.9	15.0[1]	0.58	0.31	0.68	0.46
OSU 30806 (paratype)	24.0[1]	12.8[1]	9.8[1]	8.0[1]	18.2[1]	0.53	0.30	0.76	0.44

[1] Estimate.

ventral lobe of the holotype and paratype require additional explanation, as such differences can be used to distinguish different taxa. We believe this difference is a product of septal crowding and that the posterior portion of the animal was responding to a mechanical problem in septal formation. Similar situations are known to exist (see Nassichuk, 1975, p. 101, text-fig. 38A). Such occurrences are in our opinion not important taxonomic characters.

Occurrence.—2 specimens total; Columbiana unit: holotype from loc. Cs-7; paratype from loc. Cs-16.

Repository.—Holotype, OSU 18736; paratype, OSU 30816.

Somoholites saundersi n. sp.
Pl. 2-4, figs. 3, 11

Somoholites sagittarius Saunders, 1971, text-fig. 5B.

Diagnosis.—*Somoholites* having ventrolateral saddle of suture equal in width to inflated lateral lobe, flexure in the umbilical saddle reduced to a flattened interval on umbilical shoulder, and dorsolateral lobe highly inflated and asymmetrical.

Material.—*Somoholites saundersi* is represented in the Ohio collections by two specimens. Both specimens are partial phragmocones that retain the dorsal shell and imprints of the internal sutural configuration of the unpreserved, more mature whorls.

Description.—Conch moderately evolute, juveniles (D est. = 10.2 mm) more evolute than lateral developmental stages (D = 22.0 mm). Conch measurements and proportions given in table 2-3. Dorsal shell covering conch almost to umbilical shoulder. Umbilical shoulder and area between shoulder and umbilical seam retaining external test that is without ornament except for a faint longitudinal ridge located on umbilical shoulder; point of contact (= umbilical seam) for next whorl of conch slightly ventrad of this ridge. External suture (fig. 2-5A) characterized by highly asymmetrical ventral prongs; ventrolateral saddle inflated and rounded, lateral lobe moderately pouched; umbilical saddle having a slight flexure located at position of umbilical shoulder; the umbilical lobe asymmetrically placed between umbilical shoulder and seam. Internal suture (from now-missing next whorl) having strongly inflated lobes and saddles; dorsolateral lobe markedly asymmetrical (fig. 2-6).

Remarks.—*Somoholites saundersi* n. sp. can be distinguished from other species of the genus on the basis of conch proportions and the sutural configuration. Conchs of described species of *Somoholites* that are somewhat similar to *S. saundersi* include *S. glomerous* Ruzhencev, 1950, *S. merriami* (Miller & Furnish, 1940), *S. deroeveri* Saunders, 1971, *S. beluense* (Haniel, 1915), and *S. sagittarius* Saunders, 1971. However, the sutural configurations of these taxa are significantly different from that of *S. saundersi* to warrant its separation as a distinct taxon. The ventral prongs of *S. glomerous* are more symmetrical and the ventrolateral saddle and lateral lobe are less inflated. *Somoholites beluense* differs by having a less inflated ventrolateral saddle and more symmetrical prongs of the ventral lobe. *Somoholites deroeveri* has a more symmetrical dorsolateral lobe in the internal suture, the umbilical lobe is nearer to the umbilical shoulder, and the ventrolateral saddle is more angular. *Somoholites sagittarius* is probably more closely related to *S. saundersi*; however, *S. sagittarius* has a more pronounced sutural flexure in the umbilical saddle, a greater constriction of the lateral lobe, and less pronounced inflation of the dorsolateral lobe.

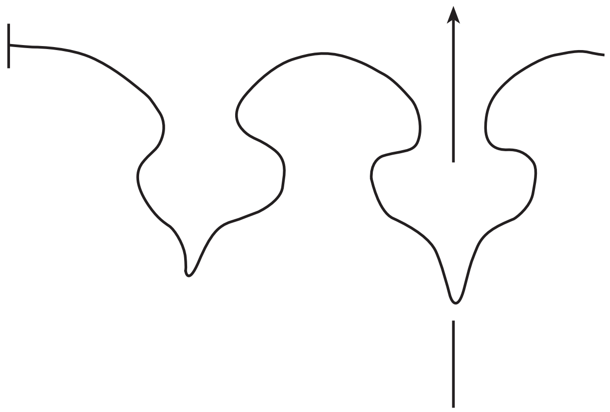

FIGURE 2-6.—Sutural outline of internal suture of *Somoholites saundersi* n. sp. Suture is taken from the exposed surface of holotype and represents a portion of the next whorl, which is no longer preserved. Washingtonville unit, loc. CAr-2; OSU 30805. Estimated diameter for the conch = 27 mm and assumes no sudden change in conch proportions.

We have included in our synonomy the juvenile specimen Saunders (1971) described from the Wewoka Formation (Desmoinesian) in Oklahoma. Placement of this specimen (SUI 34145) into *S. sagittarius* or *S. saundersi* is problematic because the conch is a juvenile; however, that the specimen is a *Somoholites* is unquestionable. We have elected to place the specimen in *S. saundersi* because of the similarities in the widths of the lateral lobe.

A striking feature of both specimens of *S. saundersi* is that they retain an exceptionally pronounced dorsal shell that shows the traces of the internal suture from a now-missing septate whorl. In addition, the holotype retains an impression and an entire shell of the encrusting brachiopod *Crania* sp. Neither the attachment impression nor the entire brachiopod are covered with dorsal shell of the ammonoid. These facts suggest that in the interval of time after the death of the ammonoid but before burial of the conch, the body chamber and at least one complete volution of the phragmocone of the holotype of *S. saundersi* were removed by natural processes. After removal of this part of the conch, the brachiopods attached to the remaining part of the phragmocone and grew to diameters of 2.3 mm and 6.8 mm. Thus, the degree of completeness exhibited by the holotype of *S. saundersi* is not a product of nonpreservation after burial.

Etymology.—This species is named for W. Bruce Saunders.

Occurrence.—2 specimens; Washingtonville unit: loc. CAr-2.

Repository.—Holotype, OSU 30805; paratype, OSU 30806.

Genus *Dimorphoceratoides* Furnish & Knapp, 1966

Type species: *Dimorphoceratoides campbellae* Furnish & Knapp, 1966, p. 305-306, pl. 35, figs. 4, 5; text-fig. 5; OD

Diagnosis.—Neodimorphoceratid possessing a relatively primitive sutural configuration in mature stage. Elements of divided ventral prongs strongly dissimilar, ventralmost elements nonacuminate, tertiary ventral saddles rounded and having divergent flanks, length significantly shorter than conspicuous lateral sutural deflection on ventral side of adjacent lateral saddles. Sutural formula = $(V_{1\cdot1}V_{1\cdot2}V_{1\cdot2}V_{1\cdot1})$ LU:ID.

Remarks.—To date, *Dimorphoceratoides* remains a monospecific genus that has only been studied in detail from its type locality in the Kendrick Shale Member of the Breathitt Formation in Kentucky. This taxon is phylogenetically intermediate between the neodimorphoceratid genera *Cymoceras* McCaleb, 1964 from the Morrowan of Arkansas and the younger (Desmoinesian) *Neodimorphoceras* Schmidt 1925. *Dimorphoceratoides* has well-defined bifid subdivisions of the ventral prong, as does *Neodimorphoceras*. However, in the most primitive representative of the family, *Cymoceras*, subdivision of the ventral element is only suggestively incipient (see McCaleb, 1968, fig. 24).

The advanced condition of *Neodimorphoceras* in comparison to *Dimorphoceratoides* is shown best in the form of the bifid lobes of the ventral prong. In *Dimorphoceratoides* only the lateral elements of the prong are suggestive of acuminate form, whereas in younger genera both elements are definitely acuminate. Other differences include a higher first lateral saddle, near-equal proportion of the lobes and saddles of the ventral prong, and subequal height of the tertiary median saddle and secondary saddle of the ventral lobe. *Shuichengoceras* Yin, 1935, a neodimorphoceratid of uncertain evolutionary position, displays angular to subangular and unequal secondary and tertiary subdivisions of the ventral lobe (Beghtel, 1962).

Conch shape of all genera in the Neodimorphoceratidae is subdiscoidal or discoidal in mature representatives, but immature shells are generally subglobular to subdiscoidal. *Neodimorphoceras*, the youngest known member of the family, is more or less lenticular or discoidal through all growth stages.

In terms of ornament, *Cymoceras* bears sinuous transverse ribs on the immature and adult shell; however, it apparently possesses no longitudinal ornament. *Dimorphoceratoides* retains fine transverse ribs on the immature conch and ventral longitudinal lirae on conchs up to a diameter of 50.0 mm. *Neodimorphoceras* (*N. texanum*) has ornament similar to *Dimorphoceratoides*, but it is confined to younger ontogenetic stages. *Shuichengoceras* also bears longitudinal ornament. In ?*S. politum* (Shumard), ornament is faint during adolescence, fine but well-developed when nearing maturity, and faint again in mature to "gerontic" individuals (Miller and Owen, 1939). It should be noted here that longitudinal ornament is a common shell feature in several Paleozoic ammonoid groups; however, the combination of conch shape, ornament, and unique sutural development distinguish members of the Neodimorphoceratidae.

Geologic and geographic range.—This taxon has been described in detail only from the Kendrick Shale Member of the Breathitt Formation (Morrowan) in Kentucky. The Ohio specimen described here is from the Lowellville (Poverty Run) unit (Pottsville Group). Other, less well studied representatives have been reported from the Winslow Formation (upper Morrowan) in Arkansas (Furnish and Knapp, 1966; Saunders and others, 1977). Insofar as it is known, this genus is endemic to North America.

Dimorphoceratoides campbellae Furnish & Knapp, 1966
Pl. 2-4, fig. 4

Dimorphoceratoides campbellae Furnish & Knapp, 1966, pl. 35, figs. 4, 5, text-fig. 5.

Diagnosis.—This taxon is monospecific; the diagnosis of the species is the same as that of the genus.

Material.—*Dimorphoceratoides campbellae* is represented in the Ohio collections by a single specimen that is laterally crushed. However, diagnostic features of the suture are sufficiently well preserved for identification purposes.

Description.—Approximate diameter of preserved portion of conch is 30.0 mm; at same diameter whorl height is about 20.0 mm and umbilical width (Umax) is 2.5 mm. All but final 10.0 mm of preserved form is phragmocone. Shell largely deteriorated but remnants of longitudinal ornament visible. Preservation of septa only fair; good representation of secondary saddle of ventral prong, umbilical region, and internal suture not available. Because of mechanical flattening of phragmocone, our reconstruction of sutural pattern (fig. 2-7) may be inexact.

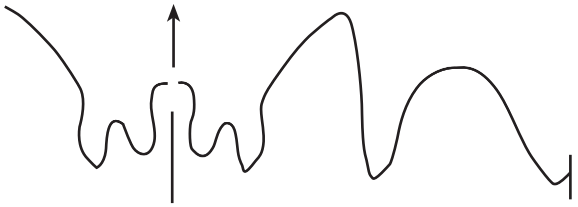

FIGURE 2-7.—Sutural outline of a hypotype of *Dimorphoceratoides campbellae* Furnish & Knapp at diameter of approximately 30 mm. Lowellville (Poverty Run) unit, loc. Tfr-1; OSU 30730. Because of the crushed nature of the specimen, this sutural outline can only be considered an approximation.

Remarks.—The Ohio specimen described here is similar in sutural development to *Neodimorphoceras lenticulare* (Girty, 1911) from the Wewoka Formation of Oklahoma (Beghtel, 1962), particularly in submature stages (diameter approximately 10 mm) of *N. lenticulare*. Corresponding sutural development in the Ohio representative occurs at a larger size, suggesting a close relationship to the older genus.

Kentucky representatives of *D. campbellae* (Furnish and Knapp, 1966) occur jointly with at least three other ammonoid genera and species: *Diaboloceras neumeieri* Quinn & Carr, 1963; *Gastrioceras occidentale* (Miller & Faber, 1892) and *Neoicoceras elkhornense* (Miller & Gurley, 1896). Of these three genera, only *Gastrioceras* has been collected from the same horizon in Ohio as *D. campbellae*. Unfortunately, specific identification of those Lowellville (Poverty Run) specimens assigned to *Gastrioceras* is not possible owing to their imperfect preservation. The occurrence of *D. neumeieri* and *G. occidentale* suggests a late Morrowan age for the Kentucky material.

Occurrence.—One specimen; Lowellville (Poverty Run) member: loc. Tfr-1.

Repository.—Hypotype, OSU 30730.

Genus *Gastrioceras* Hyatt, 1884

Type species: *Ammonites listeri* Sowerby, 1812, by subsequent designation of Foord & Crick, 1897, p. 226

Diagnosis.—Conch subdiscoidal to subglobose, umbilicus moderate to wide; umbilical shoulder nodose. Ornament ranging from simple transverse lirae to reticulate pattern in some species. Suture characteristically having a high median saddle between attenuated prongs of ventral lobe; lateral lobe generally nearly symmetrical and becoming attenuated on mature specimens.

Remarks.—*Gastrioceras* (*sensu lato*) has been used as a catchall genus and has included a large number of species that have since been placed in other genera, some of them as type species for particular genera. For instance, Girty (1915, p. 252-253) listed more than 30 North American species in several groupings; most of these species are now referred to other genera. Fifty years later, Gordon (1964, p. 252) listed 31 species from North America, Asia (China), Europe (widespread), and North Africa (Algeria and Morocco), but only seven of the 31 species are listed for North America. He placed four of the North American species in the subgenus *Branneroceras*, three in the subgenus *Lissogastrioceras*, and none in *Gastrioceras*. These seven species have been reported in Arkansas, Oklahoma, and Texas (Midcontinent region), Nevada (Cordilleran region), Alaska, and the Canadian Arctic, and they probably occur in Illinois (Eastern Interior Basin) and Ohio (Appalachian Basin). Thus, it is not surprising that Manger and Saunders (1980) indicated that the taxonomy of the Gastrioceratidae has been a source of controversy that remains to be resolved. Other significant studies of the genus *Gastrioceras* (*sensu lato*) and/or the family include those by Ramsbottom and Calver (1960), Patteisky (1965), Ruzhencev and Bogoslovskaya (1971), and Nassichuk (1975). The Ohio material lends little to the resolution of the taxonomy of the family or the genus *Gastrioceras* because of the sparse and relatively poorly preserved nature of the specimens. In fact, we have placed some of the Ohio specimens within *Gastrioceras* (*sensu lato*) with reservation because of the juvenile nature of the specimens and the lack of diagnostic ornament across the venter.

Geologic and geographic range.—*Gastrioceras* (*sensu lato*) has been recovered from middle Morrowan through probably middle Desmoinesian strata in North America. European and North African occurrences are from the Namurian to early Westphalian. Occurrences in the former Soviet Union appear to be restricted to the Kayalian (= upper Morrowan).

Gastrioceras sp.

Pl. 2-5, fig. 8; pl. 2-6, figs. 4, 5

Diagnosis.—More mature conchs subdiscoidal, juveniles subglobose; all having nodes on umbilical shoulder. Ornament, where preserved, consisting of transverse lirae.

Material.—*Gastrioceras* sp. is represented in the Ohio collections by eight specimens; a ninth specimen is now lost. Four of these specimens are juveniles (D = <15.0 mm); of the remaining four, two are laterally flattened, another is a partially complete body chamber that has traces of a crushed phragmocone, and the fourth consists of pieces of test including umbilical nodes. The lost specimen was a juvenile (pl. 2-5, fig. 8).

Description.—Precise measurements not possible on largest (D = approx. 40 to 50 mm) conchs (OSU 30820, 30706, 30819) because of lateral crushing. However, these specimens indicate conch was probably subglobose and umbilicus was moderate to moderately small. Two specimens (OSU 30820, 30706) retain impressions of fine transverse growth lines. Most complete specimen (OSU 30820) has approximately 15 nodes in umbilical shoulder in last volution. Remainder of collection composed of incomplete phragmocones and fragments of test. Conchs of phragmocone specimens moderately evolute and have pronounced nodes on umbilical shoulders. Where preserved, test has transverse growth lines. Suture pattern of larger specimens not preserved. Most complete suture pattern available exhibited on specimen OSU 30720 (fig. 2-8B) at an estimated diameter of 11.0 mm: prongs of ventral lobe short, symmetrical, and slightly inflated; lateral lobe relatively long and V shaped, umbilical lobe widely V shaped; saddles on both external and internal suture widely rounded; dorsolateral lobe of internal suture slightly asymmetrical and dorsal lobe slightly inflated. On less mature specimen (OSU 30719, fig. 2-8A) ventral prongs less attenuated and lateral lobe somewhat wider and V shaped at an estimated diameter of 8.0 mm.

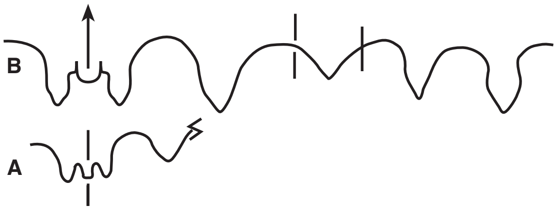

FIGURE 2-8.—Sutural outlines of *Gastrioceras* sp.
A, external suture at estimated diameter of 8.0 mm. Putnam Hill unit, loc. Ty-3; OSU 30719. Suture is slightly asymmetrical.
B, external and internal suture at estimated diameter of 11.0 mm. Putnam Hill unit, loc. Mc-2; OSU 30720.

Remarks.—We have elected to place this lot of Ohio specimens in *Gastrioceras* sp. (*sensu lato*) on the basis of conch form (where preserved), presence of umbilical nodes, and presence of transverse lirae. There are other genera, such as *Cancelloceras* Ruzhencev & Bogoslovoskaya, 1969, *Retites* McCaleb, 1964, and others, that have similar conch forms plus umbilical nodes to which these specimens could be assigned and that are known to occur within this approximate time interval. However, these taxa have reticulate ornament. Additional comparison is not warranted because of the overall poor preservation and juvenile nature of the specimens.

Occurrence.—9 specimens total; 1 specimen (from an unknown locality) now lost; Lowellville (Poverty Run) unit: 4 specimens from loc. Tfr-1; Lower Mercer unit: 2 specimens from loc. MUje-1; Putnam Hill unit: 1 specimen each from locs. Ty-3 and Mc-2.

Repository.—OSU 30706, 30719, 30720, 30817 to 30821.

Genus *Paralegoceras* Hyatt, 1884

Type species: *Goniatites iowensis* Meek & Worthen, 1860,
p. 471; OD

Diagnosis.—Conch subdiscoidal; early volutions may be triangularly coiled and have distinctive umbilical nodes. Early volutions having reticulate ornament. Suture 10 lobed. Sutural formula = $(V_1V_1)LU_1{:}U_2ID$.

Remarks.—*Paralegoceras* is intermediate among the Schistoceratidae in terms of sutural development and degree of coiling of the immature conch. The suture consists of 10 lobes, five of which are external. *Paralegoceras* represents an advancement in complexity over the slightly older *Diaboloceras* Miller & Furnish, 1940. In *Diaboloceras*, the suture may have eight lobes in more primitive species and 10 lobes in more advanced species. However, in the 10- lobed species, seven of the lobes are external and the secondary umbilical lobe (U_2), which is external, is not well developed. That same element (U_2), which lies immediately inside the seam in *Paralegoceras*, is small and asymmetrical but distinct.

Triangular coiling of the immature whorls, a characteristic that distinguishes all members of the Schistoceratidae except *Schistoceras* Hyatt, is best developed in *Paralegoceras* (for example, see pl. 2-4, fig. 7). The peculiar coiling is pronounced to a diameter of approximately 20 mm and recognizable to diameters of about 40 mm.

During the Middle Pennsylvanian, *Paralegoceras* gave rise to *Eoschistoceras* Ruzhencev, 1952, a genus in which the complexity of the umbilical portion of the suture increased slightly, but also in which the triangular coiling of the immature whorls is less distinct.

Geologic and geographic range.—North American occurrences of *Paralegoceras* include the upper Morrowan-lower Atokan (Winslow Formation) of northwest Arkansas; the Atokan of Texas, Oklahoma, and Arkansas; the Desmoinesian (Cherokee Formation) of Iowa; and the lower Desmoinesian of Oklahoma (Boggy and Deese Formations and the Buckhorn Asphalt) and Texas (Millsap Lake Formation). Other occurrences of the genus elsewhere in the world commonly are questionable and restudy of the described material is desirable before generic-level identifications can be made with confidence. Some of these occurrences include Peru (*fide* Nassichuk, 1975, p. 148); the former Soviet Union (Rakusz, 1932), Japan (Nishida, 1971), Spain (Schmidt, 1955), and Algeria (Termier and Termier, 1950).

?*Paralegoceras* sp.
Pl. 2-5, fig. 4 (compare pl. 2-4, fig. 7)

Material.—?*Paralegoceras* sp. is represented in the Ohio collections by a single incomplete phragmocone preserved in limestone.

Description.—Conch diameter 96.0 mm, estimated width 26.0 mm; height and umbilical diameters cannot be determined. Small patch of reticulate test preserved on venter approximately a volution from aperture. Sutural configuration preserved on venter and lateral areas of conch (fig. 2-9). Prongs of ventral lobe separated by relatively high median saddle and markedly asymmetrical. Ventrolateral lobe U shaped and lateral lobe asymmetrical. Remainder of sutural configuration not preserved.

Remarks.—This specimen is placed with reservation in *Paralegoceras* on the basis of the reticulate ornament and on the partly complete sutural configuration. It is equally possible that the specimen could belong to *Diaboloceras* Miller & Furnish, 1940, as the critical diagnostic features for both genera (*i.e.*, the shape and position of the lobes in the umbilical area) are not preserved. Because both of these genera range from Morrowan to Desmoinesian, the stratigraphic position of this Ohio specimen does not aid in providing a suggested identity between these two genera. *Wellerites* Plummer & Scott, 1937 and *Eowellerites* Ruzhencev, 1957a, a related schistoceratid, are much thinner than the Ohio specimen and their sutures do not have an adventitious ventral lobe. *Eoschistoceras* Ruzhencev, 1952 is a closely related genus; however, it is only known from middle Desmoinesian to lower Missourian strata in the Midcontinent, and the Lower Mercer unit from which the Ohio specimen was recovered is probably upper Atokan. Thus, it is unlikely, although not impossible, that this Ohio specimen is a specimen of *Eoschistoceras*.

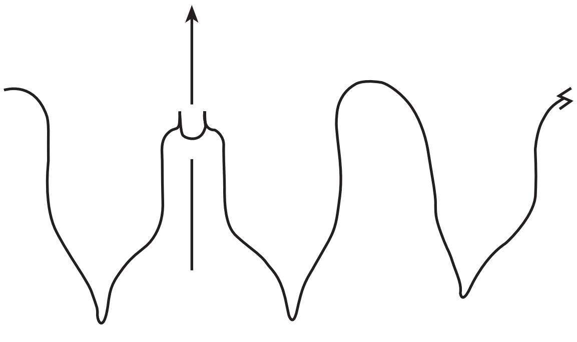

FIGURE 2-9.—Sutural outline of specimen of ?*Paralegoceras* sp. at estimated diameter of 96.0 mm. Lower Mercer unit, loc. Mbe-1; OSU 30804.

Occurrence.—1 specimen; Lower Mercer unit: loc. Mbe-1.

Repository.—OSU 30804.

Genus *Eoschistoceras* Ruzhencev, 1952

Type species: *Eoschistoceras turkestanicum* Ruzhencev, 1952, p. 913-916, pl. 1; OD

Diagnosis.—Primitive schistoceratid characterized by triangular coiling in early volutions; sutural configuration, especially between umbilical shoulder and seam, provides primary diagnostic characteristic. Sutural formula = $(V_1V_1)LU_1(U_{2\cdot2}U_{2\cdot1}:U_{2\cdot2})ID$ (Ruzhencev, 1962); U_1 element typically well developed and forming a nearly symmetrical V shape.

Remarks.—Plummer and Scott (1937) first recognized the intermediate nature of this taxon and introduced the name *Pintoceras* (type species: *P. postvenatum*) for it. However, Plummer and Scott did not illustrate the holotype and stated that no illustration could be offered until better material was obtained. Beghtel (1962) correctly contended that the genus was introduced as a concept, a practice not allowed by the International Commission on Zoological Nomenclature rules. Miller and Furnish (1958) later attempted to validate the taxon, but discovered that the holotype was either mislabeled or missing. Those authors then set up a homeotype, which they illustrated along with other conspecific material. However, Ruzhencev (1952) had previously established the genus *Eoschistoceras* for these forms and that name is herein recognized as the valid designation.

Septate conchs of *Eoschistoceras* are known to attain diameters up to 148 mm (Beghtel, 1962); for an example see plate 2-4, figure 1. The umbilicus is wide in immature conchs and narrows at maturity. Conch shape is thickly subdiscoidal to subglobose in forms of 20.0 mm diameter and less, but is narrower in mature shells. Inner whorls are triangularly coiled and evolute; the conch becomes more involute at maturity. Immature ornament consists of transverse umbilical ribs that persist to diameters of 30.0 mm. Mature ornament consists of transverse growth lamellae that show a ventral hyponomic sinus and longitudinal lirae on the umbilical regions ventrad of the shoulder.

Triangular coiling is weakly displayed in *Branneroceras* (see McCaleb, 1968), is better developed in *Diaboloceras*, and is best developed in *Paralegoceras*. Although this characteristic is present in *Eoschistoceras*, it is perhaps less pronounced. Triangular coiling is considered to be absent in both *Paraschistoceras* and *Schistoceras* (Miller and Furnish, 1958; Ruzhencev and Bogoslovskaya, 1978).

In the Schistoceratidae, the umbilical lobe (U_1) phylogenetically migrates ventrally, as in *Paralegoceras*, and is replaced by development of incipient elements dorsad of the umbilical shoulder, as in *Eoschistoceras*. *Eoschistoceras* generally possesses as many sutural elements as *Paraschistoceras* and *Schistoceras*; however, the auxiliary lobes of the umbilical complex are smaller and not well established in terms of size. Thus, *Eoschistoceras* has an intermediate sutural configuration between the more primitive *Paralegoceras* and the more advanced *Paraschistoceras*, in that *Paralegoceras* develops a single, well-developed, somewhat asymmetrical secondary umbilical lobe (U_1) that is positioned ventrad of the umbilical shoulder. Also in *Paralegoceras*, another umbilical lobe (U_2) migrates dorsorad and becomes part of the internal suture. *Eoschistoceras* develops a V-shaped secondary umbilical lobe (U_1) in the same position; however, two or in some cases three tertiary umbilical lobes develop between the umbilical shoulder and seam. On more mature specimens (D = 50.0 mm+) of the more advanced species of this genus, one of these lobes ($U_{2\cdot2}$) migrates ventrad of the umbilical shoulder. *Paraschistoceras* has the same number of umbilical lobes as the more advanced members of *Eoschistoceras*. In *Paraschistoceras* the umbilical-lobe element U_1 migrates ventrad around the umbilical shoulder, as does the umbilical-lobe element $U_{2\cdot2}$. Umbilical element $U_{2\cdot1}$ remains between the umbilical shoulder and seam, and the other umbilical element ($U_{2\cdot2}$) migrates dorsorad to become part of the internal suture. Migration of these umbilical elements occurs midway in the ontogenetic sequence and probably takes place by a conch diameter of 25 mm. Thus, a gradational overlap is to be expected between the more advanced species of *Eoschistoceras* and the more primitive species of *Paraschistoceras*. Definition of an artifical boundary and species composition between these two genera remains to be accomplished.

Geologic and geographic range.—Representatives of *Eoschistoceras* are relatively uncommon, although occurrences are widespread. At this time, we accept three species with reservations. The type species, *Eoschistoceras turkestanicum* Ruzhencev, 1952, comes from the Jigulian Series (Middle Pennsylvanian) of the Turkestan Range in Asia. Beghtel (1962) reported *E. strawnense* (*Paraschistoceras strawnense* Plummer & Scott, 1937) from the Wewoka and Wetumka Formations and the Buckhorn Asphalt (Desmoinesian) of Oklahoma. Miller and Owen (1937) described a representative of *Eoschistoceras* from the "Seminole Formation" (upper Desmoinesian) as *Schistoceras unicum*. That species is slightly advanced over *E. strawnense*, but has triangularly coiled inner whorls. North American representatives thus seem to be confined to rocks of the Desmoinesian Series.

?*Eoschistoceras* sp.
Pl. 2-5, fig. 1

Material.—?*Eoschistoceras* sp. is represented in the Ohio collections by a single septate internal mold consisting of approximately one-third volution. The individual is laterally crushed and is incomplete on both the umbilical and ventral areas.

Description.—Diameter at septate adoral margin of crushed conch exceeding 100.0 mm, corresponding height approximately 60.0 mm. Conch width and umbilical diameter cannot be measured. Nearly all of external suture available, only a small portion of the critical umbilical suture being missing (fig. 2-10). Because of substantial crushing, proportions and details of suture are a best estimate. Lobes of ventral prong acuminate and subequal in comparison to slightly lanceolate lateral lobe. V-shaped lateral lobe and second lateral lobe (U_1) nearly symmetrical. Umbilical saddle approximately one-half the length of second lateral lobe and subdivided by at least a single incipient inflection. Position of umbilical shoulder as well as configuration of umbilical sutural element(s) in doubt. Position of umbilical seam more certain.

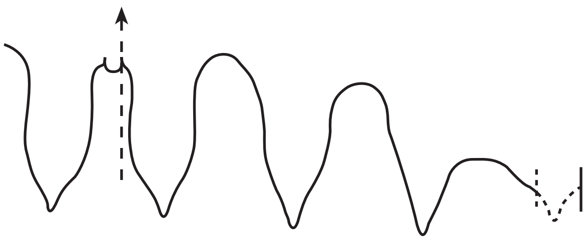

FIGURE 2-10.—Sutural outline of specimen of ?*Eoschistoceras* sp. at estimated diameter of 100 mm. Putnam Hill unit, loc. Ms-3; OSU 30725.

Remarks.—Because the critical portion of the sutural configuration in the umbilical area is not preserved, our placement of this specimen in *Eoschistoceras* is made with reservation. *Paralegoceras* has a much more asymmetrical U_1 sutural element and we are confident that this specimen does not belong to that taxon. It is possible that this specimen is a primitive *Paraschistoceras*, as in the primitive forms of this taxon the secondary umbilical lobe ($U_{2\cdot2}$) does not migrate ventrad across the umbilical shoulder. The preserved portion of the suture of the Ohio specimen is remarkably similar to that of *E. strawnense* (Plummer & Scott, 1937) as illustrated by Beghtel (1962, text-fig. 30c) from the Buckhorn Asphalt in Oklahoma.

Occurrence.—1 specimen; Putnam Hill unit: loc. Ms-3.

Repository.—OSU 30725.

Genus *Schistoceras* Hyatt, 1884

Type species: *Goniatites missouriensis* Miller & Faber,
1892, p. 164, pl. 6, fig. 1; OD

Diagnosis.—Schistoceratid characterized by lack of triangular coiling in earlier whorls; umbilical nodes expressed only during juvenile stages of ontogeny (D = 12 to 24 mm). Sutural formula (Ruzhencev, 1962) = $(V_1V_1)LU_1U_{2\cdot2}U_{2\cdot1}{:}U_{2\cdot2}ID$. Sutural elements $U_{2\cdot2}$, $U_{2\cdot1}$, and $U_{2\cdot2}$ migrate at diameters of 10 to 15 mm.

Remarks.—The morphological features that allow precise separation of *Schistoceras*, which is the youngest and most advanced genus of the Schistoceratidae in the Pennsylvanian, and *Paraschistoceras* are not well defined (see remarks under *Paraschistoceras*). *Schistoceras* seems to differ from *Paraschistoceras* in that the migration of the secondary umbilical elements of the suture takes place by a diameter of 15 mm. In the Ohio specimens, the loss of umbilical nodes does not always coincide with migration of the secondary umbilical lobes of the suture. In one specimen, lobe migration is complete by a diameter of 12 mm, but nodes are retained up to a maximum preserved diameter of 24 mm. Another specimen loses the umbilical nodes and the umbilical-lobe migration almost simultaneously at a conch diameter of 13 to 15 mm. Thus, there is considerable variation in the conch diameters at which umbilical nodes are lost, but umbilical-lobe migration is less variable. In addition, on some as yet undescribed "*Schistoceras*" specimens from

Texas, the umbilical diameters are much smaller and the conchs are more involute than any specimens in the Ohio collections. As indicated under Remarks for *Paraschistoceras*, additional studies are necessary, as the Ohio material can only contribute to but not resolve the taxonomic problems involved in *Paraschistoceras* and *Schistoceras*.

Geologic and geographic range.—Representatives of *Schistoceras* appear to range from Missourian through Virgilian strata (Upper Pennsylvanian) in North America. Miller and Furnish (1940) reported a possible Permian occurrence in Texas. *Schistoceras* also occurs in the Upper Carboniferous of the former Soviet Union (Ruzhencev, 1950).

Because *Schistoceras* co-occurs with *Paraschistoceras* at numerous Upper Pennsylvanian localities, the all-inclusive synonomy of Miller and Furnish (1940) will require the restudy of numerous described and undescribed specimens before a precise geologic range and occurrence can be determined for *Schistoceras*. Plummer and Scott (1937) recognized nine species of *Schistoceras*; however, we suspect that some of these are only variations of previously described taxa within the genus.

Schistoceras spp.
Pl. 2-3, figs. 1-6, 9, 13

Diagnosis.—Ventral and dorsal migration of secondary umbilical lobes completed by conch diameters of 15 mm.

Material.— The Ohio collections contain four specimens of *Schistoceras* spp. Two specimens (SUI 1437 and SUI 48921) are silicified phragmocones. Specimen OSU 30705 is an internal mold in limestone that preserves no sutural detail. Specimen OSU 30703 is a well-preserved partly complete internal mold. Specimen TUP 8173 from the Brush Creek unit in Pennsylvania is a well-preserved internal mold of the phragmocone and is included here for comparison.

Description.—Conch fairly involute at larger diameters, earlier whorls exhibiting variation in degree of involution. Conch measurements and proportions given in table 2-4. Conch diameter at point of umbilical-node loss variable, specimen SUI 48921 losing umbilical nodes at a conch diameter of 13.0 to 15.0 mm but specimen OSU 3073 retaining umbilical nodes to maximum preserved conch diameter of 24.0 mm. Ornament reticulate where preserved, transverse lirae dominant over longitudinal and forming a well-developed hyponomic sinus, ventrolateral salient, and ocular sinus. Sutural configurations of available specimens variable. On most mature specimens (specimen SUI 1437, D at suture = 36.0 mm; specimen TUP 8173, D at suture = 45.0 mm) prongs of ventral lobe separated by a high median saddle having nearly parallel sides (figs. 2-11C, 2-11D). Prongs somewhat asymmetrical and slightly inflated, tips moderately attenuated. Lateral lobe nearly symmetrical, slightly inflated, and more bluntly pointed than prongs of ventral lobe. Primary umbilical lobe located slightly less than midway between venter and umbilical shoulder, slightly asymmetrical and more attenuated than lateral lobe. Secondary umbilical-lobe element $U_{2\cdot 2}$ located ventrad of umbilical shoulder and markedly asymmetrical. Slight flexure at the umbilical shoulder and V-shaped secondary umbilical-lobe element ($U_{2\cdot 1}$) located midway between umbilical shoulder and seam. Migration of the secondary umbilical-lobe element taking place at conch diameter of 13.0 to 15.0 mm. On less mature specimen (OSU 30703, D = 22.0 mm), median saddle between prongs of ventral lobe having distinctly asymmetrical sides and ventral prongs more attenuated (figs. 2-11A, 2-11B). Lateral lobe more asymmetrically inflated, as is the primary umbilical-lobe element. Umbilical-lobe element $U_{2\cdot 2}$ slightly inflated and

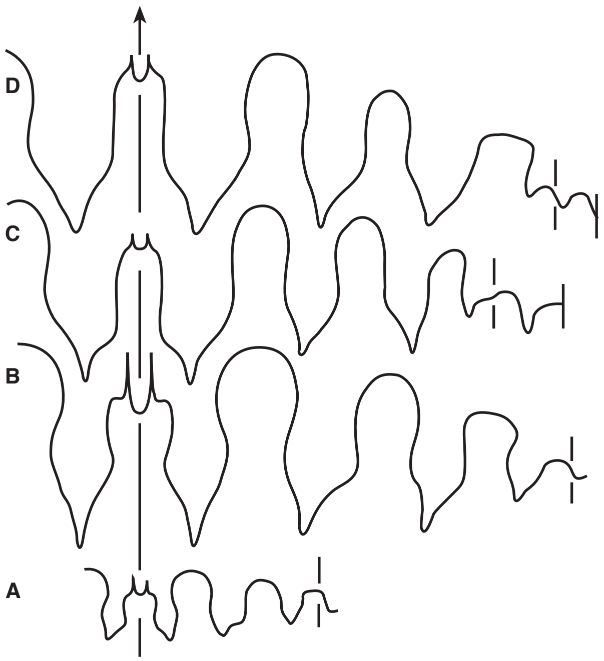

FIGURE 2-11.—Sutural outlines of *Schistoceras* spp.
A, **B**, at diameters of 10.8 mm (**A**) and 22.0 mm (**B**). Ames unit, loc. MUu-2; OSU 30703.
C, at diameter of 36.0 mm. Cambridge unit, loc. Ga-1; SUI 1437.
D, at estimated diameter of 45.0 mm. Brush Creek unit, brickyard at Creighton, near Pittsburgh, Pennsylvania; TUP 8173.

TABLE 2-4.—*Conch measurements and ratios of* Schistoceras *spp.*

Specimen	D (mm)	Umax (mm)	Umin (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
Ames unit									
OSU 30703	24.0	14.3	8.1	9.0	15.0				
	10.8[1]			3.0	7.7		0.28	0.71	0.39
Cambridge unit									
SUI 1437	46.0	12.5	10.1	23.0	23.7	0.27	0.50	0.52	0.97
	27.7	9.2[1]	7.0[1]	13.0	17.0	0.33	0.47	0.61	0.76
	17.8			7.9[1]	10.8[1]		0.44	0.61	0.73
SUI 48921	47.2	14.9	11.1	23.9	22.4[1]	0.32	0.51	0.47	1.06
OSU 30705	68.5	18.0	13.1	33.0	31.3	0.26	0.48	0.46	1.05

[1] Estimate.

more symmetrical; pronounced shallow flexure at position of umbilical shoulder. Umbilical-lobe element $U_{2\cdot1}$ poorly preserved, although lobe is present approximately midway between umbilical shoulder and seam.

Remarks.—There appear to be two distinct forms among the Ohio specimens. One form is typified by specimen OSU 30703, which has more attenuated prongs of the ventral lobe and retains umbilical nodes up to the maximum preserved diameter. The other form, typified by specimens SUI 1437 and TUP 8173, has more inflated prongs of the ventral lobe and loses the umbilical nodes in an earlier stage of the ontogeny. Because of the taxonomic problems associated with *Eoschistoceras*, *Paraschistoceras*, and *Schistoceras* (see descriptions of these three genera), we have elected to refrain from assigning names to these two distinct forms. Detailed studies of these genera and their species are necessary before taxonomic determination of the Ohio specimens can be made.

Occurrence.—4 specimens total; Cambridge unit: 1 specimen each from locs. Gwe-1 and Ga-1; ?Cambridge unit: 1 specimen from loc. MUuc-6; Ames unit: 1 specimen from loc. MUu-2.

Repository.—OSU 30703, 30705; SUI 1437, 48921; TUP 8173.

Genus *Paraschistoceras* Plummer & Scott, 1937

Type species: *Ammonites hildrethi* Morton, 1836, p. 144, pl. 1, fig. 24 (also perhaps pl. 28, figs. 48, 50, 53, 54); OD

Diagnosis.—Schistoceratid characterized by lack of triangular coiling in earlier whorls; some conchs moderately evolute and retain umbilical nodes up to diameters of 30.0 mm. More mature conchs moderately involute and lacking umbilical nodes. Sutural formula (Ruzhencev, 1950) = $(V_1V_1)\ LU_1U_{2\cdot2}U_{2\cdot1}U_{2\cdot2}ID$. Migration of $U_{2\cdot2}$ elements takes place at diameters of 25 to 30 mm.

Remarks.—Plummer and Scott (1937) established this genus on the basis of conch proportions, umbilical nodes, and the sutural configuration in the umbilical area of the conch. Three years later, Miller and Furnish (1940, p. 538) reexamined the then-available specimens of *Schistoceras*, *Paraschistoceras*, and *Eoschistoceras* (*sensu* this report) and concluded that all of the previously described genera (including *Paraschistoceras*) and species (more than 10) could be suppressed as junior synonyms of *Schistoceras hildrethi* and *S. missouriense.* Despite the evidence presented by Miller and Furnish in 1940, Ruzhencev (1950) used *Paraschistoceras* for his new species *P. optatum*. Ruzhencev (1952, 1957a, 1962), and Ruzhencev and Bogoslovskaya (1978) have continued to recognize the taxonomic validity of the genus, whereas North American workers, for example, Miller and Downs (1950), Miller and others (1957), Nassichuk (1975), and others, have accepted *Paraschistoceras* as a junior synonym of *Schistoceras*.

Thus, it is readily apparent that reanalysis of specimens assigned to *Paraschistoceras* and *Schistoceras* is needed. The Ohio specimens that we are assigning to these genera are limited in quality of preservation, and the few specimens in the collection have been recovered from only a few of the many marine units in the Appalachian Basin. Thus, this material will not significantly aid in solving the taxonomic problem. However, the marine horizons in the southern Midcontinent (Texas, Oklahoma, and Kansas) are known to contain numerous well-preserved specimens of the *Eoschistoceras/Paraschistoceras/Schistoceras* complex in what may be the most complete Middle and Upper Pennsylvanian marine stratigraphic succession in North America and perhaps the world. Study of these specimens is beyond the scope or purpose of this report; future workers will have to analyze specimens from those richly fossiliferous units and resolve the systematic parameters in the *Eoschistoceras/Paraschistoceras/Schistoceras* complex.

In order to evaluate the Ohio material, a preliminary study of more than 200 undescribed Middle and Upper Pennsylvanian Midcontinent schistoceratids was initiated. These specimens suggest to us that the study by Miller and Furnish was too inclusive and that *Paraschistoceras* is probably a valid intermediate genus between *Eoschistoceras* and *Schistoceras*. Generic-level characteristics that separate these three genera are difficult to define precisely until a definitive study is accomplished. However, morphological features that appear to be significant are as follows: the ontogenetic stage at which migration of the umbilical lobes occurs, conch size when umbilical nodes are lost, the degree of reduction in triangular coiling in the earliest volutions, and conch proportions during early ontogeny. It is probable that evolutionary gradations of one or more of these morphological features will be discovered in these two genera.

In our generic diagnosis of *Paraschistoceras* (and also *Schistoceras*) we cite the sutural formula provided by Ruzhencev (1962). We are not confident that this sutural formula is entirely correct or complete, as relatively few ontogenetic studies have been made on species assigned to these genera. Furthermore, we have observed specimens of "*Schistoceras*" in our undescribed Midcontinent collections that have a small but distinct lobe on the umbilical shoulder that develops after the $U_{2\cdot2}$, $U_{2\cdot1}$, $U_{2\cdot2}$ umbilical elements have migrated to their final positions. Miller and Furnish (1940, text-fig. 6B) illustrate the beginning of this lobe at a diameter of about 35 mm.

The marked difference in the umbilical sutural configuration of two similar-sized "*Schistoceras*" specimens (compare OSU 30703, fig. 2-11B, with OSU 30704, fig. 2-12) suggests that there is a primitive form in which migration of the umbilical sutural elements takes place relatively late in the ontogeny (conch diameter between 25 to 30 mm) and a coexisting advanced form in which the umbilical lobes migrate at a much earlier stage of the ontogeny (conch diameter between 10 to 15 mm). We have elected to place the more primitive form from Ohio in *Paraschistoceras* and the more advanced forms in *Schistoceras*.

As could be expected, coexistence of two generally similar and definitely related forms suggests the possibility of sexual dimorphism. Sexual dimorphism has been suggested for morphological variations observed in primitive genera

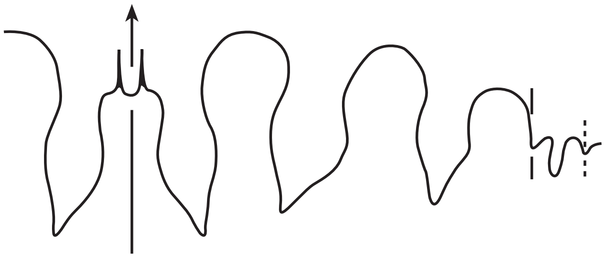

FIGURE 2-12.—Sutural outline of specimen of *Paraschistoceras* sp. at estimated diameter of 22.0 mm. Brush Creek unit, loc. Cma-8, OSU 30704.

assigned to the Schistoceratidae (McCaleb and Furnish, 1964; Furnish and Knapp, 1966; Mapes and Furnish, 1981). There are no incontrovertible criteria that define sexually dimorphic characters in Paleozoic ammonoids (Davis, 1972). However, Davis and others (1996, p. 472) state ". . . it must be concluded that the late-ontogenetic shell modifications in ammonoids are, in fact, mature modifications." The differences that we suggest separate *Paraschistoceras* and *Schistoceras* may be, at least in part, sexual. We believe it best at this time to establish separate taxa for these possible sexual dimorphs because the criteria for sexual dimorphism in Paleozoic ammonoids have not been firmly established.

Geologic and geographic range.—The geologic range of *Paraschistoceras* is not precisely known at this time. In their original description of the genus, Plummer and Scott (1937) indicated that the following four species could be recognized in North America:

P. strawnense (considered here to be *Eoschistoceras*), from strata at the Desmoinesian-Missourian boundary in Texas;
P. hildrethi (Morton), from Upper Pennsylvanian strata in Illinois and Virgilian strata in Texas; the type of the genus is from the Cambridge unit (Missourian) in Ohio;
P. costiferum, from Missourian strata in Texas;
P. reticulatum, also from Missourian strata.

If the taxonomy of Plummer and Scott (1937) is correct, then the age range for *Paraschistoceras* is Missourian and Virgilian (Upper Pennsylvanian). Ruzhencev (1950, 1952, 1957a, 1962) indicated that *Paraschistoceras* has been recovered from the Upper Carboniferous (Zhighlevian and Orenburgian) of the Ural Mountains and in Central Asia.

Paraschistoceras sp.
Pl. 2-6 , figs. 6, 7

Diagnosis.—Conch widely umbilicate, umbilical nodes at maximum preserved diameter. Sutural configuration having two umbilical lobes ($U_{2\cdot2}$ and $U_{2\cdot1}$) confined to area between umbilical shoulder and umbilical seam in early ontogeny (D est. = 22 mm); in later stages of development, umbilical element nearest umbilical shoulder migrating ventrad.

Material.—*Paraschistoceras* sp. is represented in the Ohio collections by a single, incomplete, nontestiferous phragmocone.

Description.—Conch moderately evolute, umbilicus relatively wide. Conch measurements (estimated) and ratios: D = 22.0 mm, H = 5.4 mm, W = 14.0 mm, Umax = 11.0 mm, Umax/D = 0.5, H/D = 0.25, W/D = 0.64, H/W = 0.39. Approximately 20 umbilical nodes present on preserved one-half whorl. Sutural configuration at diameter of 22.0 mm (fig. 2-12) having attenuated, symmetrical, and slightly inflated prongs of ventral lobe, lateral lobe, and first umbilical lobe; saddles generally rounded and symmetrical; three secondary umbilical lobes ($U_{2\cdot2}$, $U_{2\cdot1}$, $U_{2\cdot2}$) essentially confined to area between umbilical shoulder and umbilical seam, but umbilical lobe closest to umbilical seam begins to migrate to become part of internal suture.

Remarks.—Species-level determination of the single Ohio specimen cannot be undertaken until the taxonomy of *Paraschistoceras* and *Schistoceras* is better understood. We have placed this single specimen in *Paraschistoceras* because of the marked sutural difference exhibited by a similar-sized specimen which we believe to be *Schistoceras* that was recovered slightly higher in the Ohio stratigraphic succession. The single specimen assigned to *Paraschistoceras* displays a suture pattern at a conch diameter of 22.0 mm similar to that of relatively mature specimens of *Eoschistoceras*. Undoubtedly, more mature specimens from this horizon will show the complete migration of the umbilical elements to positions similar to those seen in late juvenile stages of *Schistoceras*.

Occurrence.—1 specimen; Brush Creek unit: loc. Cma-8.

Repository.— OSU 30704.

Genus *Wellerites* Plummer & Scott, 1937

Type species: *Wellerites mohri* Plummer & Scott, 1937; p. 376-378, pl. 38, figs. 13-16, text-fig. 81; OD

Diagnosis.—Mature conch evolute and discoidal; umbilical ribbing present on juvenile forms. Suture having 20 to 22 lobes, adventitious lobe developing in first lateral saddle, four or five pairs of auxiliary umbilical lobes. Sutural formula = $(V_1V_1)L^1LU_1U_2U_3U_4 \ldots ID$.

Remarks.—*Wellerites mohri* was first described by Plummer and Scott in 1937 on the basis of a single poorly preserved specimen that was recovered from an isolated outcrop on the Llano River, $1^1/_2$ miles (2.4 km) east and 4 miles (6.4 km) south of London, Kimble County, Texas. Because of its isolated occurrence and lack of associated fauna, Plummer and Scott suggested a Mississippian age for this taxon. Shortly after their report was published, additional specimens from Desmoinesian strata in north-central Texas came to their attention, and in 1938 they correctly noted this taxon was of Middle Pennsylvanian age. No additional specimens have been recovered from the type exposure.

Since that time, additional specimens of this genus have been recovered elsewhere in North America. In 1938, in a privately published report on the cephalopods of the Buckhorn Asphalt in southern Oklahoma, Smith described the occurrence of *W. mohri* and erected two new species, *W. vulgaris* and *W. plummeri*. Miller and Sturgeon (1946) described two specimens of *Wellerites* sp. from Ohio but declined to assign the specimens to a new taxon despite recognizing that the suture pattern is unique. Ruzhencev (1952) described *W. russiensis* from the Ural Mountains in the former Soviet Union. Miller and Furnish (1958) reported additional details on the specimens of *Wellerites* from Texas, and, on the basis of a well-preserved juvenile recovered from the Wewoka Formation in Oklahoma, described the development of the adventitious lobe in the first lateral saddle during ontogeny. In a survey of the cephalopods of Oklahoma, Unklesbay (1962) recorded the discovery of an additional specimen from the Buckhorn Asphalt. In that same year, Beghtel compiled an excellent summary of this genus. Beghtel analyzed the Buckhorn material in detail and noted a large degree of sutural variation within the genus. Mapes and Furnish (1981) reillustrated a sutural ontogeny based on specimens from the Wewoka Formation, confirmed the close kinship with the older genus *Eowellerites*, and noted a new occurrence of the genus from the Deese Formation in southern Oklahoma.

The Ohio collections consist of eight specimens from three units. Sutural characteristics of these specimens show some variation when compared with each other and with the Midcontinent material. None of the Ohio specimens of *Wellerites* is considered to be mature. In fact, most specimens are relatively smaller than those that have been reported in the literature. Thus, comparison of the types of *W. mohri*, *W. russiensis*, and other specimens, which may not be conspecific with *W. mohri* but which have been assigned to that taxon, must await additional ontogenetic analysis and/or recovery of additional material. *Wellerites mohri* Plummer & Scott and *Wellerites russiensis* Ruzhencev are now regarded with reservation as being valid species of *Wellerites*. We have elected to refer the Ohio specimens to *Wellerites* cf. *W. mohri* until a complete generic analysis is accomplished.

Geologic and geographic range.—The type specimen for *Wellerites* was recovered from an isolated exposure in central Texas. Specimens tentatively assigned to *W. mohri* have been recovered from north-central Texas (Millsap Lake Formation), southern Oklahoma (Buckhorn Asphalt and Deese Formation), and central Oklahoma (Wewoka and Holdenville Formations). *Wellerites* cf. *W. mohri* has been recovered from northeastern Ohio (Putnam Hill unit) and east-central Ohio (Columbiana and Washingtonville units). *Wellerites russiensis* was recovered from Middle Carboniferous units in the Ural Mountains in the former Soviet Union.

Wellerites cf. *W. mohri* Plummer & Scott, 1937
Pl. 2-3, figs. 7, 8, 10-12; pl. 2-6, figs. 8-12

Wellerites sp. Miller & Sturgeon, 1946, p. 387-389, pl. 56, figs. 6, 7, 8, 9, text-fig. 3A, B.

Diagnosis.—*Wellerites* having relatively unsplayed, nearly symmetrical to asymmetrical prongs of ventral lobe during earlier stages of ontogeny (D = 28.0 mm). Adventitious lobe varying from blunt and unattenuated to well attenuated (D = 13.0 to 14.0 mm).

Material.—*Wellerites* cf. *W. mohri* is represented in the Ohio collections by eight specimens. Most of the specimens are partly crushed to uncrushed phragmocones; several display the internal sutures of a now missing whorl.

Description.—Conch discoidal, venter rounded. Measurements and proportions of better preserved specimens given in table 2-5. Earliest juvenile stages poorly exposed on several specimens; one (OSU 18738) having faint traces of 25-30 umbilical nodes at a diameter of about 4.0 mm; another (OSU 30728) having umbilical nodes crossed by relatively coarse transverse growth lines, but ornamented growth lines on lateral and ventral portions obscured by dorsal shell. Longitudinal lirae preserved on dorsal shell of specimen OSU 30728 orad of last internal suture. At a diameter of 10.5 mm, internal mold retaining impression of relatively coarse transverse growth lines that form a pronounced hyponomic sinus. Remaining specimens of *Wellerites* cf. *W. mohri* provide little additional information in that where external shell is preserved, test is smooth. Suture patterns described and illustrated (figs. 2-13, 2-14, 2-15) separately because of variations in sutures of specimens from each stratigraphic unit and differences observed in configuration of ventral prongs and degree of development of adventitious lobe.

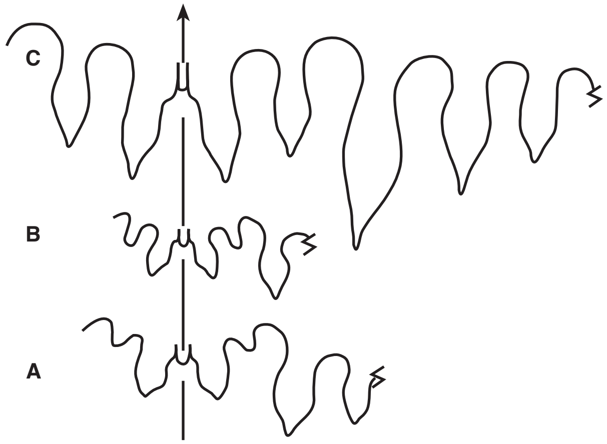

FIGURE 2-13.—Sutural ontogeny of *Wellerites* cf. *W. mohri* Plummer & Scott as demonstrated by two hypotypes from the Putnam Hill unit.

A, **B**, at diameters of 10.5 mm (**A**) and 14.0 mm (**B**). Loc. Mg-4; OSU 18738.
C, at diameter of 28.8 mm. Loc. Me-5; OSU 30822.

Suture patterns of Putnam Hill specimens best displayed on specimens OSU 18738 and 30822 (fig. 2-13). During early ontogenetic stages (D = 10.5 mm), ventral lobe has relatively unsplayed, bluntly pointed asymmetrical prongs and adventitious lobe only moderately developed and bluntly rounded. By a diameter of 14.0 mm, prongs of ventral lobe more attenuated and adventitious lobe better developed but still bluntly rounded. At a diameter of 28.0 mm, prongs of ventral lobe and adventitious lobe attenuated and pointed.

Suture patterns of specimens from Columbiana unit best displayed on OSU 30726 (fig. 2-14). At a diameter of 25.0 mm, prongs of ventral lobe attenuated, asymmetrical, and moderately inflated and adventitious lobe well developed and pointed. At a diameter of 45.5 mm, prongs of ventral lobe more symmetrical. Early ontogeny of specimens from this unit at diameters of less than 25.0 mm remains unknown.

Suture patterns of specimens from Washingtonville unit

TABLE 2-5.—*Conch measurements and ratios of* Wellerites *cf.* W. mohri

Specimen	D (mm)	Umax (mm)	Umin (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
Putnam Hill unit									
OSU 18738	16.1			6.2[1]	4.3		0.39	0.27	1.44
OSU 30822	28.6	8.4	6.2	13.7	8.7[1]	0.29	0.48	0.30	1.57
Columbiana unit									
OSU 18739	60.0[1]			24.9	16.5[1]		0.42	0.28	1.51
OSU 30726	45.5	15.0[1]		20.0	13.4	0.33	0.44	0.29	1.49
Washingtonville unit									
OSU 30728	13.2	3.2[1]		6.4[1]	4.8	0.24	0.48	0.36	1.33
OSU 30731	28.5	7.2	5.0[1]	13.7	9.3	0.25	0.48	0.33	1.47

[1] Estimate.

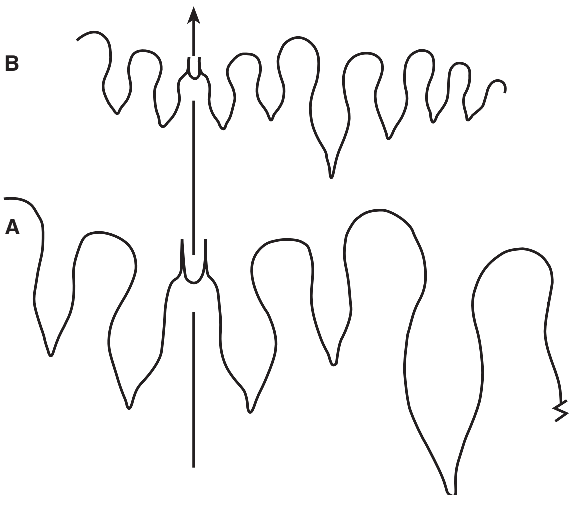

FIGURE 2-14.—Sutural ontogeny of *Wellerites* cf. *W. mohri* Plummer & Scott as demonstrated by a hypotype from the Columbiana unit, loc. Cs-3; OSU 30726. Estimated diameters = 25 mm (**A**) and 45.5 mm (**B**).

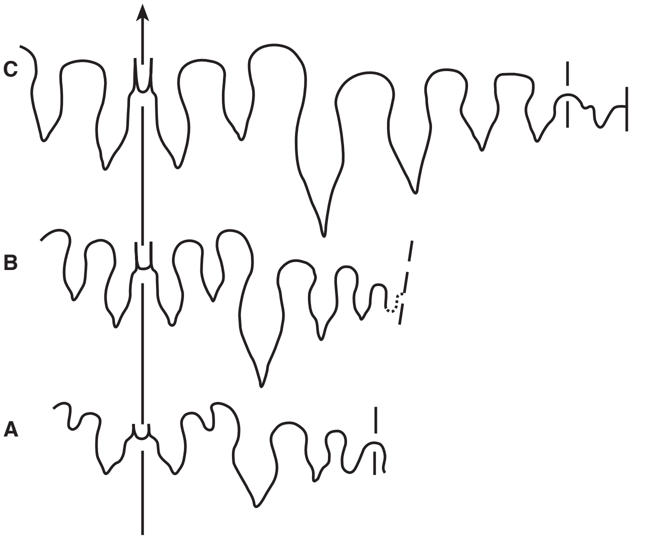

FIGURE 2-15.—Sutural ontogeny of *Wellerites* cf. *W. mohri* Plummer & Scott as demonstrated by two hypotypes from the Washingtonville unit, loc. CAr-2.

A, **B**, at estimated diameters of 7.0 mm (**A**) and 13.0 mm (**B**). OSU 30728.

C, at diameter of 27.0 mm. OSU 30731.

best preserved on OSU 30728 and 30731 (fig. 2-15). Sutures indicate rapid development of adventitious lobe in first lateral saddle; prongs of ventral lobe nearly symmetrical and unsplayed. At a diameter of 7.0 mm, prongs of ventral lobe relatively blunt and adventitious lobe relatively narrow and rounded. By a diameter of 13.0 mm, prongs of ventral lobe more attenuated and adventitious lobe has become markedly longer and more attenuated. Attenuation of these lobes continues throughout remainder of known ontogeny and prongs of ventral lobe remain relatively unsplayed.

Remarks.—On the basis of the sutural differences observed in the Ohio and Midcontinent specimens of *Wellerites*, it is likely that several species will eventually be isolated from *W. mohri*. Critical features undoubtedly will include the rate of development of the adventitious lobe, symmetry and degree of splaying of the ventral prongs, and the rate at which umbilical sutural elements are added to the lateral portion of the phragmocone during ontogeny. A complete restudy of this genus is necessary before these species can be identified with confidence; therefore, we have elected to place the Ohio specimens in *W. mohri* with reservations.

Occurrence.—8 specimens total; Columbiana unit: 1 specimen each from locs. Cp-3 and Cs-3; Putnam Hill unit: 1 specimen each from locs. Mc-2, Mc-5, and Mg-4; Washingtonville unit: 3 specimens from loc. CAr-2.

Repository.—OSU 18738, 18739, 30726 to 30729, 30731, 30822.

Genus *Pennoceras* Miller & Unklesbay, 1942

Type species: *Pennoceras seamani* Miller & Unklesbay, 1942; p. 146-148, pl. 8, figs. 7-13, text-fig. 2B; OD

Diagnosis.—Conch globose and involute; ornament of coarse transverse lirae. Suture goniatitic; prongs of ventral lobe shallow and U shaped, lateral saddle rounded, lateral lobe bluntly pointed, slightly inflated, and V shaped.

Remarks.—The assignment of *Pennoceras* to the family Wiedeyoceratidae was reviewed by Ruzhencev and Bogoslovskaya (1978); they placed this genus in this family with strong reservation. They concluded that the phylogenetic position of this genus is unknown and that it differs in many respects from the genus *Wiedeyoceras* within that family. We have chosen to accept their placement of *Pennoceras*, as we do not have a better alternative at this time. *Wiedeyoceras* has bluntly pointed prongs of the ventral lobe, whereas *Pennoceras* has U-shaped prongs. The conch of *Wiedeyoceras* is thinner and has much finer ornament than that of *Pennoceras*. *Bisatoceras* differs from *Pennoceras* in having much more inflated prongs of the ventral lobe.

Geologic and geographic range.—*Pennoceras* has only been recovered from the Brush Creek and Pine Creek units of the Conemaugh Group in western Pennsylvania and the Brush Creek unit in eastern Ohio.

Pennoceras seamani Miller & Unklesbay, 1942
Pl. 2-1, figs. 11, 13

Goniatites lunatus Raymond (*non* Miller & Gurley), 1910, p. 156; 1911, p. 85, 86, 88, 96.

Pennoceras seamani Miller & Unklesbay, 1942, p. 146-148, pl. 8, figs. 7-13, text-fig. 2B; 1947, p. 325-326, pl. 2, figs. 3, 4; Sturgeon & Miller, 1948, p. 80; Miller, Furnish & Schindewolf, 1957, p. L60; Ruzhencev, 1962, p. 377-378, pl. 21, figs. 10a, b, text-fig. 144; Windle, 1970, p. 116-117, pl. 2, fig. 3.

Diagnosis.—This genus is monospecific; thus, the diagnosis of the species is the same as that of the genus.

Material.—Collections from the Carnegie Museum, the University of Iowa, and The Ohio State University provide a total of 26 specimens; of these, nine are from Ohio. All of the Ohio specimens are partly to completely crushed, although all retain their distinctive coarse transverse ornament. Only a single specimen (OSU 30802) has a recrystallized phragmocone inside the body chamber.

Description.—Conch involute, umbilicus closed (fig. 2-16). Conch proportions and ratios given in table 2-6. Conspicu-

TABLE 2-6.—*Conch measurements and ratios of* Pennoceras seamani

Specimen	D (mm)	Umax (mm)	Umin (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
CM 22292 (lectotype)	16.0	2.5[1]		9.1	9.5[1]	0.16	0.57	0.59	0.96
OSU 30801 (hypotype)	14.0[1]	3.0		7.6	9.8[1]	0.21	0.54	0.70	0.77
OSU 30802 (hypotype)	15.2[1]	4.0		9.0	11.0[1]	0.26	0.59	0.72	0.82
	4.5	0.5		2.2	3.2	0.11	0.49	0.71	0.68
SUI 9531A (hypotype)	11.3	1.8	0.5	6.5	8.5	0.16	0.58	0.75	0.76
SUI 9531B (hypotype)	10.8	2.5		6.3	8.1	0.23	0.58	0.75	0.78

[1] Estimate.

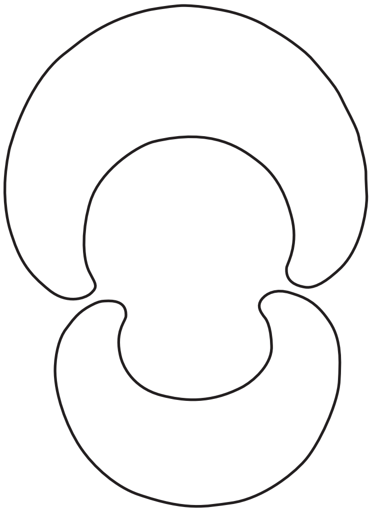

FIGURE 2-16.—Cross section of specimen of *Pennoceras seamani* Miller & Unklesbay at diameter of 11.2 mm. Brush Creek unit, Glassmere, Pennsylvania; SUI 9531A.

ous coarse transverse lirae on test impressed on internal mold. One Ohio specimen (OSU 30802) that has a recrystallized phragmocone is involute; sutures not preserved. Suture of specimen CM 25801 from Pennsylvania possessing relatively narrow, U-shaped, slightly asymmetrical prongs of ventral lobe, rounded lateral saddle, widely V-shaped and bluntly pointed lateral lobe, and rounded umbilical saddle (fig. 2-17).

Remarks.—Miller and Unklesbay (1942, p. 147-148) based their description on three syntypes (CM 22292, 22293, and 22294), one (CM 22292) of which they figured in their plate 8, figures 7-9. We are designating this specimen as the lectotype for the species. This taxon appears to be endemic to the Appalachian Basin. To date, only eastern Ohio and western Pennsylvania have yielded specimens referable to the species.

Occurrence.—26 specimens total; Brush Creek unit: 8 specimens from loc. Aa-41; 1 specimen (part and counterpart) from loc. Cma-5; 5 specimens from Glassmere, PA; 3 specimens each from Creighton and Donohoe, PA; 2 specimens each from Witmer, Sewickley, and Ligonier, PA.

Repository.—Lectotype, CM 22292; paratypes, CM 22293, 22294; topotypes, CM 22758, 25804; hypotypes, CM 379 to 381, 22045, 22575, 22577, 22750, 25801 to 25803, 33803 to 33805, SUI 9531A and B, OSU 19606, 30707, 30708, 30801, 30802.

Genus *Gonioglyphioceras* Plummer & Scott, 1937

Type species: *Gonioloboceras welleri gracile* Girty, 1911, p. 153; 1915, p. 263-264, pl. 35, figs. 3-5b; OD

Diagnosis.—Mature conch discoidal and involute, possessing narrow retuse venter on exterior of test. Eight-lobed suture at maturity having relatively rounded to pointed ventral prongs, wide to narrowly rounded to bluntly pointed asymmetrical first lateral saddle, and relatively broadly rounded to bluntly pointed lateral lobe; lateral lobe typically equal to or higher than prongs of ventral lobe.

Remarks.—Relatively mature representatives of this genus generally possess strongly compressed conchs which bear distinctive furrowed venters on the shells. Where test is lacking, the internal mold commonly displays a narrow flattened area on the ventral periphery just above the siphuncle. Traces of this diagnostic feature are evident as early as diameters of 12.0 mm. The shell is relatively thin except on the venter, where the furrow and bounding keels are developed (fig. 2-18). Growth lines are faint and show a moderately narrow hyponomic sinus, an adjacent and equally narrow salient, a broad ocular sinus, and a low salient on the umbilical shoulder. The ventrolateral surface of the conch may be slightly convex at maturity. The umbilical shoulders are narrowly rounded and distinct; the umbilicus is small (Umax/D = 0.10-0.18) at maturity (D > 22.0 mm).

Three species of *Gonioglyphioceras* have been established within the limits of this genus; however, the lack of precise stratigraphic data and lack of understanding concerning variability within the genus has resulted in lack of agreement among workers. Beghtel (1962) indicated that all representatives described to that date were conspecific with *G. gracile*.

The ancestor to *Gonioglyphioceras* was perhaps the closely related genus *Gonioloboceratoides*. The closely related genus *Gonioloboceras* appears to have coexisted at least in the Middle Pennsylvanian in the Midcontinent (Miller and Downs, 1950; Unklesbay, 1962). Thus, it appears that both

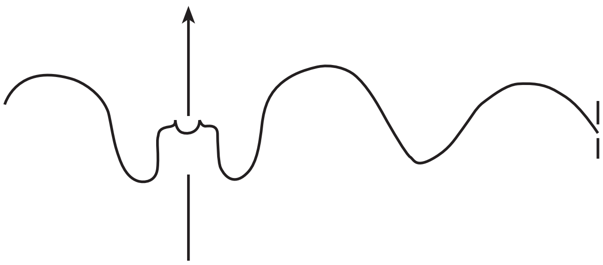

FIGURE 2-17.—Sutural outline of specimen of *Pennoceras seamani* Miller & Unklesbay at diameter of approximately 7.5 mm. Brush Creek unit, Glassmere, Pennsylvania; CM 25801.

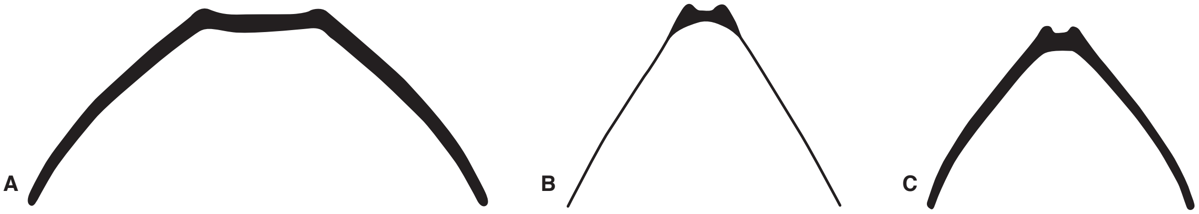

FIGURE 2-18.—Variation in bicarinate venter exhibited by various Ohio species of *Gonioglyphioceras*. All illustrations X5. **A**, ?*Gonioglyphioceras* sp. A at estimated diameter of 60 mm. Putnam Hill unit, loc. Mc-2; OSU 30791. **B**, *G. columbianaense* n. sp. at estimated diameter of 55 mm. Columbiana unit, loc. Ss-4; OSU 30790. **C**, *G. gracile* (Girty) at estimated diameter of 54 mm. Washingtonville unit, loc. CAr-2; OSU 30712.

Gonioloboceras and *Gonioglyphioceras* arose from the more primitive *Gonioloboceratoides* (Atokan).

Geologic and geographic range.—*Gonioglyphioceras* is known only from the Middle Pennsylvanian (Desmoinesian) of North America. Representatives have been reported from Illinois, Ohio, Oklahoma, and Texas. Ohio specimens have been found in the Putnam Hill, Columbiana, and Washingtonville units.

Gonioglyphioceras gracile (Girty, 1911)
Pl. 2-2, figs. 3, 5-8, 10, 12, 13

Gonioloboceras welleri gracile Girty, 1911, p. 153-154; 1915, p. 263-264, pl. 35, figs. 3-5b.

Gonioglyphioceras gracile Plummer & Scott, 1937, p. 336-337, text-fig. 68; Miller, Furnish & Schindewolf, 1957, p. L60-L61; Beghtel, 1962, p. 160-171, pl. 5, figs. 1-8, text-figs. 19, 20A-F (part); Unklesbay, 1962, p. 68-70, pl. 7, figs. 3-6.

Gonioloboceras gracile (Girty) Elias, 1938, p. 99-100 (part), pl. 20, figs. 7a, b, text-fig. 1, N-O^2.

Diagnosis.—A species of *Gonioglyphioceras* having moderately to highly compressed asymmetrical lateral saddle and bluntly pointed, V-shaped, slightly asymmetrical lateral lobe that is even with or less than one-half the distance higher than tips of prongs of ventral lobe.

Material.—*Gonioglyphioceras gracile* is represented in the Ohio collections by 11 specimens; eight are juvenile and the remaining three are more nearly mature. Most of the specimens are body chambers or are somewhat crushed and recrystallized; however, several are well-preserved, septate internal molds.

Description.—Mature conch involute and discoidal, juvenile conch more evolute and ribbed. Conch measurements and ratios given in table 2-7. Fragments of test having growth lines on juvenile specimens displaying well-developed hyponomic and ocular sinuses. Fragments (OSU 30795, 30796) of what were almost certainly mature body chambers (D est. = 90.0 mm) retaining growth lines showing well-developed salients between sinuses approximately one-third the distance from venter to umbilical area. Internal molds of these specimens showing faint longitudinal lirae and faint crenulations along crest of flattened venter. Where test is present, venter is retuse (fig. 2-18C). Approximately 13 umbilical ribs present on smallest specimen (D = 6.0 mm); ribs becoming faint and disappearing by a diameter of 8.0 mm. Sutural configuration well displayed on several well-preserved phragmocones (fig. 2-19). At a diameter of 7.0 mm, suture pattern of smallest Ohio specimen similar to similar-sized specimens from Texas and Oklahoma except that umbilical shoulder is somewhat angular. At a diameter of 19.0 mm, prongs of ventral lobe bluntly rounded and lateral saddle moderately rounded and asymmetrical. Lateral lobe V shaped and bluntly pointed. Characteristically, point of lateral saddle less than one-half the length above prongs of ventral lobe. Asymmetry of umbilical saddle not present at this or larger diameters. Essentially mature suture (D = 50.0 mm) having attenuated, essentially symmetrical, bluntly pointed prongs of ventral lobe, moderately wide to compressed asymmetrical lateral saddle, and slightly asymmetrical, broad, bluntly pointed lateral lobe.

Remarks.—*Gonioglyphioceras gracile* differs from *G. columbianaense* n. sp. by its lower, bluntly pointed lateral lobe and more compressed lateral saddle. Slight degrees of asymmetry observed on the prongs of the ventral lobe and the umbilical saddle in juvenile stages are not considered to be taxonomically significant at this time. For comparative purposes, sutural diagrams of some typical specimens of *G. gracile* from Texas and Oklahoma are provided in figure 2-20. Significant sutural features at the species level are the degree of compression of the lateral saddle and the shape and height of the lateral lobe. Considerable sutural variation is present within populations of *G. gracile* in terms of the shape and height of the lateral lobe and the shape and symmetry of the prongs of the ventral lobe. This variation is considered to be within the range of population variation. At this time the degree of taxonomic significance that should be placed on variation of cross-sectional shape (see fig. 2-18) is unknown.

Potentially, this taxon stands to be one of the better ammonoid biostratigraphic correlation tools for Middle Pennsylvanian strata (Desmoinesian of the Midcontinent and upper Pottsville and Allegheny of the Appalachian Basin). Such correlations cannot be precisely made at this time, as little work has been done on the available specimens from the Midcontinent. However, slight but possibly significant variations, including the somewhat less compressed lateral saddle and more open shape of the lateral lobe, suggest the Ohio specimens are more primitive members of this species.

Occurrence.—11 specimens; Washingtonville unit: loc. CAr-2.

Repository.—Holotype, OSU 30712; hypotypes, OSU 30711, 30794 to 30799, 30814, 48945.

Gonioglyphioceras columbianaense n. sp.
Pl. 2-2, fig. 4; pl. 2-7, fig. 1

Gonioglyphioceras sp. Miller & Sturgeon, 1946, p. 385, pl. 56, figs. 4, 5.

Diagnosis.—A species of *Gonioglyphioceras* characterized by mature suture having wide, asymmetrical lateral saddle and rounded, U-shaped lateral lobe that is more than one-

TABLE 2-7.—*Conch measurements and ratios of* Gonioglyphioceras columbianaense, G. gracile, *and* ?Gonioglyphioceras *sp. A*

Specimen	D (mm)	Umax (mm)	Umin (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
G. columbianaense n. sp.									
OSU 18734 (paratype)	45.0[1]			31.4[1]	12.5[1]		0.70	0.28	2.51
OSU 30790 (holotype)	55.0[1]			35.0	13.5[1]		0.64	0.24	2.59
OSU 30793 (paratype)	5.5	2.1	1.6	2.0	3.5	0.38	0.36	0.64	0.57
G. gracile (Girty, 1911)									
OSU 30711 (hypotype)	14.5	2.8		14.6	6.4	0.19	1.01	0.44	2.28
OSU 30712 (hypotype)	54.0	6.0		30.0	14.0	0.11	0.55	0.26	2.14
	19.0	3.2	2.0	15.0		0.17	0.79		
OSU 48945 (hypotype)	14.5	2.6	1.2	13.0	6.4	0.18	0.90	0.44	2.03
OSU 30797	22.0	4.0		11.0	7.0[1]	0.18	0.50	0.32	1.57
?*Gonioglyphioceras* sp. A									
OSU 30792	6.0[1]	2.5	2.0	2.5	3.0	0.42	0.42	0.50	0.83

[1] Estimate.

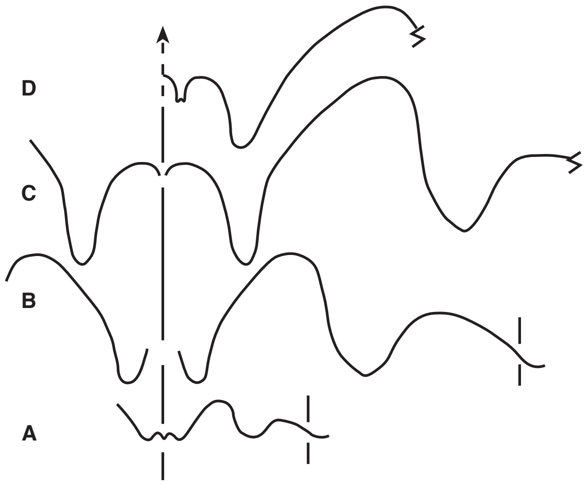

FIGURE 2-19.—Sutural outlines of hypotypes of *Gonioglyphioceras gracile* (Girty) from the Washingtonville unit, loc. CAr-2. Note marked asymmetrical displacement of ventral lobe in relation to venter.
A, at diameter of 7 mm. OSU 48945.
B, **C**, at diameters of 19 mm (**B**) and 54 mm (**C**). OSU 30712.
D, at diameter of about 50 mm. OSU 30799.

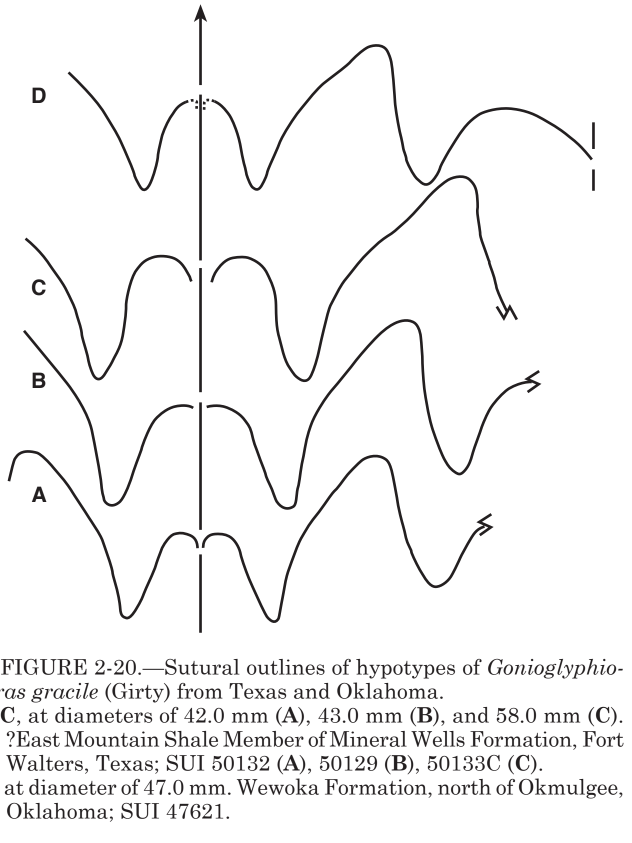

FIGURE 2-20.—Sutural outlines of hypotypes of *Gonioglyphioceras gracile* (Girty) from Texas and Oklahoma.
A-**C**, at diameters of 42.0 mm (**A**), 43.0 mm (**B**), and 58.0 mm (**C**). ?East Mountain Shale Member of Mineral Wells Formation, Fort Walters, Texas; SUI 50132 (**A**), 50129 (**B**), 50133C (**C**).
D, at diameter of 47.0 mm. Wewoka Formation, north of Okmulgee, Oklahoma; SUI 47621.

half the distance higher than tips of prongs of ventral lobe.

Material.—Gonioglyphioceras columbianaense is represented in the Ohio collections by three specimens. Two of the specimens are mature or nearly mature pieces of phragmocones; the remaining specimen is a well-preserved juvenile.

Description.—Pieces of phragmocones (OSU 18734, 30790) indicate conch was discoidal and venter was retuse at maturity (fig. 2-18B). Conch measurements and ratios for these specimens and the juvenile specimen (OSU 30793) given in table 2-7. Patches of test preserved on specimen OSU 30790, but no details of growth lines. Test preserved on specimen OSU 30793 retaining growth lines on retuse venter forming a well-developed hyponomic sinus; other details of growth lines not preserved. Specimen OSU 30793 evolute, having 11 well-developed umbilical ribs on last complete whorl; ribs more pronounced in earlier volutions than at maximum diameter of specimen (D = 5.5 mm). At maximum diameter ribs relatively faint, possibly because orad one-third of conch is poorly preserved. Sutural configuration preserved on all specimens (fig. 2-21). At a diameter of 3.0 mm, prongs of ventral lobe shallow and symmetrical and lateral saddle and lateral lobe relatively wide and symmetrical. At a diameter of 45.0 mm, prongs of ventral lobe slightly asymmetrical and bluntly rounded; lateral saddle relatively wide, asymmetrical, and broadly rounded; and lateral lobe well rounded, U shaped, and more than one-half the height of ventral prongs. At a diameter of 55.0 mm, prongs of ventral lobe symmetrical, moderately attenuated, and bluntly pointed; lateral saddle asymmetrical, rounded, and relatively wide; and lateral lobe slightly asymmetrical, well rounded, and high in relation to tips of ventral prongs.

Remarks.—Gonioglyphioceras columbianaense differs from *G. gracile* by its relatively wide, broadly rounded lateral

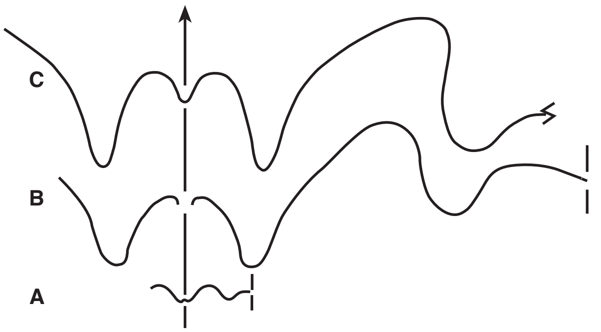

FIGURE 2-21.—Sutural outlines of two paratypes and the holotype of *Gonioglyphioceras columbianaense* n. sp. from the Columbiana unit.

A, paratype at estimated diameter of 3 mm. Loc. Ss-6; OSU 30793.

B, paratype at estimated diameter of 45 mm. Loc. Cp-3; OSU 18734.

C, holotype at estimated diameter of 55 mm. Loc. Ss-4; OSU 30790.

saddle and well-rounded, high lateral lobe at maturity. The sharply retuse venter of *G. columbianaense* and *G. gracile* separates these taxa from ?*Gonioglyphioceras* sp. A. We consider *G. columbianaense* to be more primitive than *G. gracile*, which appears to occur only in upper Desmoinesian (Marmaton Group) strata in the Midcontinent. If this is the case, the Columbiana unit may be older than the Midcontinent Marmaton units and would be equivalent to a marine incursion in the pre-Marmaton Krebs or Cabaniss Groups in the Midcontinent.

Etymology.—This species derives its name from the Columbiana unit.

Occurrence.—3 specimens total; Columbiana unit: 1 specimen from loc. Cp-3, 1 specimen from loc. Ss-4, 1 specimen from loc. Ss-6.

Repository.—Holotype, OSU 30790; paratypes, OSU 18734, 30793.

?*Gonioglyphioceras* sp. A

Pl. 2-7, figs. 2-5

Diagnosis.—Mature conch having relatively wide retuse venter. Mature sutural details unknown.

Material.—?*Gonioglyphioceras* sp. A is represented in the Ohio collections by two specimens. The most complete specimen is a well-preserved internal mold of a juvenile. The other specimen is a fragment of what is probably a mature body chamber having an aragonitic test.

Description.—Juvenile specimen (OSU 30792) evolute and ribbed. Conch measurements and proportions given in table 2-7. Ribs S shaped and most pronounced on umbilical shoulder; approximately 17 present on last volution (D = 6.0 mm). Traces of aragonitic test present; however, impressions of test on internal mold best preserve configuration of growth lines. Growth lines outlining well-developed hyponomic and ocular sinuses. Five constrictions present and follow configuration of growth lines. Exposed portion of phragmocone exhibits seven septa; however, several of these septa are damaged or distorted. On best available suture (fig. 2-22), prongs of ventral lobe shallow and wide and first lateral saddle wide and symmetrical, as are lateral lobe, umbilical saddle, and umbilical lobe. Specimen OSU 30791 is a portion of an aragonitic test-covered body chamber. Preserved faint ornament indicating presence of well-developed U-shaped hyponomic sinus on venter and ventrolateral portions of fragment. Exterior of test slightly concave on venter, as is internal mold (fig. 2-18A). Faint longitudinal lirae present on slightly raised ventral keels.

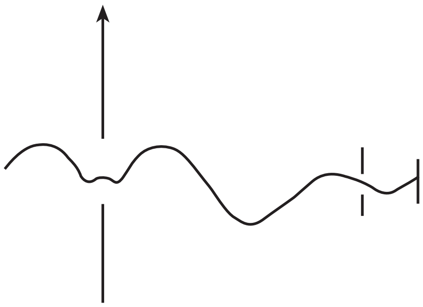

FIGURE 2-22.—Sutural outline of specimen of ?Gonioglyphioceras sp. A at diameter of 5 mm. Putnam Hill unit, loc. Mc-2; OSU 30791.

Remarks.—These specimens are referred to *Gonioglyphioceras* with reservation for several reasons. Assuming no distortion, the width of the retuse venter is strikingly dissimilar to all other described species of *Gonioglyphioceras* (compare fig. 2-18A with figs. 2-18B and 2-18C). However, because the specimens of ?*Gonioglyphioceras* sp. A would probably represent the most primitive development of the genus, on the basis of retuse venter width and features of the juvenile conch, conch similarities with the ancestral genus *Gonioloboceratoides* should be expected. *Gonioloboceratoides* is described by Nassichuk (1975) as having a rounded venter during juvenile stages but may be slightly flattened at full maturity. Evolution toward the pronounced narrowly retuse venter seen on specimens of *Gonioglyphioceras* from middle and upper Desmoinesian strata suggest that an intermediate form similar to ?*Gonioglyphioceras* sp. A should be present. Comparison of the juvenile specimen of ?*Gonioglyphioceras* sp. A is difficult because juveniles of *Gonioglyphioceras* rarely have been described. Beghtel (1962, p. 166, text-fig. 20C) illustrated a suture remarkably similar to ?*Gonioglyphioceras* sp. A and referred his specimen to *G. gracile*. Similarly, the youngest known representative of *Gonioglyphioceras*, *G. collinsvillense* (Miller & Owen) (Miller and Owen, 1937, pl. 52, fig. 7), is remarkably similar to that of ?*Gonioglyphioceras* sp. A. However, the specimens illustrated by Miller and Owen and material collected since that time indicate that ribs on *G. collinsvillense* are more pronounced, and the conch is wider than that of ?*Gonioglyphioceras* sp. A.

?*Gonioglyphioceras* sp. A is distinct in mature conch form from all other named species of the genus. However, because the Ohio material is limited and mature suture patterns cannot be obtained from the available specimens, we believe it is best to leave this taxon in open nomenclature until more mature septate specimens are recovered.

Occurrence.—2 specimens; Putnam Hill unit: loc. Mc-2.

Repository.—OSU 30791, 30792.

Genus *Mangeroceras* Sturgeon, Windle, Mapes & Hoare, 1982

Type species: *Mangeroceras canfieldense* Sturgeon, Windle, Mapes & Hoare, 1982; pl. 4, figs. 1, 2, 5, 6, text-fig. 6, table 3; OD

Diagnosis.—Subdiscoidal conch (W/D = 0.41-0.59) having depressed to compressed whorls (H/W = 0.48-1.08) and a relatively narrow umbilicus at maturity (U/D = 0.08-0.26). Early ontogeny of conch characterized by pronounced ribs on umbilical shoulder; ribs lost at diameters greater than about 15.0 mm. More mature shells relatively smooth. Growth lines forming shallow to moderate ventral sinus followed by well-developed lateral salients and shallow ocular sinus; ventrolateral sulci may be present during later stages of ontogeny. Constrictions common on some juvenile conchs are missing on relatively mature forms. External suture characterized by wide ventral lobe having shallow, bluntly pointed, V- to U-shaped ventral prongs, widely rounded lateral saddles, and widely rounded to narrow, pointed, subangular lobes nearly equal to or longer than ventral prongs; umbilical lobe V shaped.

Remarks.—Confusion regarding the concept and morphology of *Donetzoceras* has been resolved by Saunders, Manger, and Ramsbottom (1979). Sturgeon and others (1982) considered the close relationship of *Mangeroceras* and *Donetzoceras* and their work is confirmed herein. Adequate comparisons of *Mangeroceras* and *Donetzoceras* with similar-appearing taxa belonging to *Wiedeyoceras* and *Anthrococeras* are provided by Saunders and others (1979) and Sturgeon and others (1982). Additional taxa that are similar to *Mangeroceras* are *Bisatoceras* and *Wewokites*. *Mangeroceras* can be distinguished from *Bisatoceras* by the presence of umbilical ribs and its more evolute conch during early ontogeny; also, the lateral lobe of the suture of *Bisatoceras* is more inflated. *Wewokites* can be distinguished from *Mangeroceras* by its retention of umbilical lobes throughout its ontogeny and its more involute conch.

Geologic and geographic range.—All but one of the representatives of *Mangeroceras* have been recovered from the Putnam Hill unit (Allegheny Group). The single exception is a crushed body chamber from the Lowellville (Poverty Run) unit (Pottsville Group); this specimen is assigned to *Mangeroceras* with reservation. The middle-upper Desmoinesian Allegheny Group (Sturgeon and Hoare, 1968, table 3) correlates with the Westphalian C and D of Europe (Collins, 1979), and the upper Atokan-lower Desmoinesian Pottsville Group correlates with the Westphalian A and B. This taxon is only known from Ohio and is presently considered to be endemic to that region.

Mangeroceras canfieldense Sturgeon, Windle, Mapes & Hoare, 1982

Pl. 2-1, figs. 1, 3, 4, 8, 10, 12, 14; pl. 2-2, figs. 9, 14; pl. 2-4, figs. 2, 6; pl. 2-5, figs. 2, 3, 5, 7

Mangeroceras canfieldense Sturgeon, Windle, Mapes & Hoare, 1982, p. 1474-1476, text-figs. 5, 6; pl. 4, figs. 1, 2, 5, 6, table 3.

Diagnosis.—*Mangeroceras* having relatively large, parallel-sided prongs of ventral lobe and narrow, pointed lateral lobe.

Material.—*Mangeroceras canfieldense* is represented in the Ohio collections by 48 specimens. Diameters of available specimens (table 2-8) range from 5.0 to an estimated 35.0 mm. Many of the specimens are well preserved; some have aragonite tests. Others are molds of body chambers including crushed phragmocones.

Description.—Conch subdiscoidal (W/D = 0.41-0.59), whorls compressed to depressed (H/W = 0.48-1.08); umbilicus of more juvenile specimens moderately small (Umin/D = 0.18 at 13 mm diameter), umbilicus of more mature specimens more constricted (U/D = 0.08 at D = approximately 35.0 mm) (fig. 2-23; table 2-8). Juvenile conchs (D = 3.5 mm) having 14 to 16 pronounced umbilical nodes; at diameters of 13.0 to 15.0 mm, nodes becoming coarse. Crescent-shaped ribs extending approximately two-thirds the distance from shoulder to venter; 2 to 6 finer ribs present between coarse ribs, finer ribs following pattern of growth lines completely across conch. Constrictions present on some juvenile conchs not present on largest shells (D = 35 mm) in collection; largest shells possessing a smooth conch and growth lines of test exhibiting a pronounced ventral sinus, ventrolateral salients, and shallow ocular sinus. Some conchs of intermediate diameters having shallow ventrolateral sulci. External suture generally similar to sutures of species assigned to *Donetzoceras*. At maturity, suture having relatively parallel sided, pointed ventral prongs and narrow pointed lateral lobe (fig. 2-24). Slight sutural crenulations near tip of lateral lobe on some specimens not considered to have taxonomic importance at this time.

Remarks.—*Mangeroceras canfieldense* is closely related to several species of *Donetzoceras* but can be distinguished from *D. pareyni* Saunders, Manger & Ramsbottom, 1979 by its larger, more parallel sided prongs of the ventral lobe and narrower lateral lobe. *Donetzoceras donetzense* Librovich, 1939 and *D. aegiranum* Schmidt, 1925 differ from *M. canfieldense* by having shallower and more rounded lateral lobes. In addition, the degree of retention of ribbing in the ontogeny makes this endemic taxon unique.

Occurrence.—48 specimens total; Lowellville (Poverty Run) unit: 1 specimen, with reservation, from loc. Tfr-1; Putnam Hill unit: 43 specimens from loc. Mc-2, 4 specimens from loc. Ms-3.

Repository.—Holotype, SUI 11050; hypotypes, OSU 30738 to 30742; paratypes, SUI 11052, 40026 to 40034, OSU 30713, 30714, 30716, 30733 to 30737.

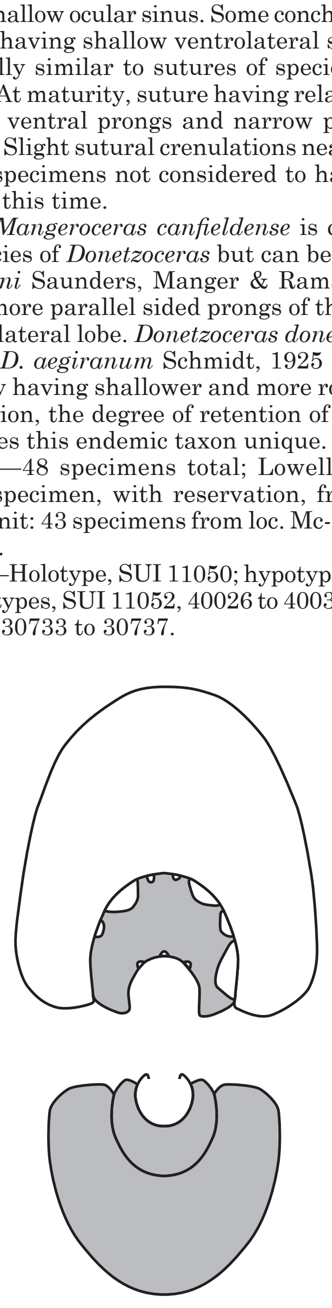

FIGURE 2-23.—Cross section of paratype of *Mangeroceras canfieldense* Sturgeon, Windle, Mapes & Hoare at diameter of 20.3 mm. Shaded area is phragmocone; remainder is body chamber. Putnam Hill unit, locality Mc-2; SUI 40027. From Sturgeon and others (1982).

TABLE 2-8.—*Conch measurements and ratios of selected specimens of* Mangeroceras canfieldense[1]

Specimen	D (mm)	Umax (mm)	Umin (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
OSU 30733 (paratype)	13.0	3.8	2.4[2]	3.5	7.2	0.18	0.27	0.55	0.48
OSU 30734 (paratype)	11.8	4.5	3.1[2]	4.0	4.9	0.26	0.33	0.41	0.81
OSU 30735 (paratype)	15.0	4.0	2.7	6.2	8.0	0.18	0.41	0.53	0.78
SUI 11050 (holotype)	13.1	3.5	2.5	4.3	7.8	0.19	0.33	0.59	0.55
SUI 40027 (paratype)	20.3	4.4	2.7	6.7	10.0	0.13	0.33	0.49	0.67
SUI 40028 (paratype)	35.0[2]	4.2	2.8	12.6	15.5[2]	0.08	0.36	0.44	0.81
SUI 40029 (paratype)	29.0[2]	4.8	2.5	11.1	13.0	0.09	0.38	0.45	0.85
SUI 40031 (paratype)	15.1	3.9	2.9[2]	5.2	8.8	0.19	0.34	0.58	0.59
SUI 40033 (paratype)	28.1	5.0	3.0	14.0[2]	13.0	0.11	0.50	0.46	1.08

[1] From Sturgeon and others (1982, table 3, p. 1475).
[2] Estimate.

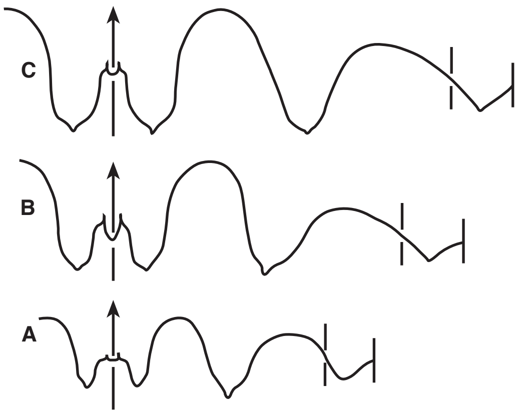

FIGURE 2-24.—Sutural outlines of paratypes of *Mangeroceras canfieldense* Sturgeon, Windle, Mapes & Hoare from the Putnam Hill unit, locality Mc-2. From Sturgeon and others (1982).
A, at estimated diameter of 14 mm. SUI 40028.
B, at estimated diameter of 18 mm. SUI 40026.
C, at estimated diameter of 35 mm. OSU 30713.

Genus *Gonioloboceras* Hyatt, 1900

Type species: *Goniatites goniolobus* Meek, 1877, p. 98-99, pl. 9, figs. 5-5b; OD

Diagnosis.—Mature conch subdiscoidal, umbilicus relatively small, and venter rounded. Suture characterized by broad ventral lobe having relatively narrow prongs and an angular first lateral saddle.

Remarks.—A general review of the literature indicates that *Gonioloboceras* and the relatively closely related *Gonioglyphioceras* Plummer & Scott, 1937 and *Mescalites* Furnish & Glenister, 1971 have been subject to a great deal of taxonomic confusion. This confusion has been caused by lost type specimens, lack of precise locality information, availability of relatively few specimens from many localities, and especially the virtually complete set of morphological changes developed in the juvenile through mature stages of development. The work of Plummer and Scott (1937), Elias (1938, 1962), Miller and Downs (1950), and Furnish and Glenister (1971) seems to have stabilized the concept of these three genera.

Separation of relatively mature *Gonioloboceras* from *Gonioglyphioceras* and *Mescalites* rests on the configuration of the ventral lobe and the shape of the venter of the conch. Both *Gonioglyphioceras* and *Mescalites* have venters that show a markedly flattened to bicarinate nature; *Gonioloboceras* has a rounded venter. In terms of the suture, the ventral lobe of *Mescalites* has a well-developed tertiary ventral element adjacent to the siphuncle. This sutural element is missing or has only begun to develop in *Gonioloboceras* (see fig. 2-25C). In *Gonioglyphioceras*, the ventral lobe is narrower and the prongs are generally less attenuated than in *Gonioloboceras*. The closely related genera *Mangeroceras* Sturgeon, Windle, Mapes & Hoare, 1982 and *Donetzoceras* Librovich, 1946 can be distinguished from juvenile specimens of *Gonioloboceras* by their less attenuated ventral lobes, rounded ventrolateral lobe, and retention of umbilical nodes at larger diameters. *Gonioloboceratoides* Nassichuk, 1975 (see pl. 2-2, fig. 11) was established on the basis of somewhat older (Atokan) and less suturally advanced specimens from the Canadian Arctic. The major difference Nassichuk noted between *Gonioloboceras* and *Gonioloboceratoides* is that the prongs of the ventral lobe of *Gonioloboceratoides* are more bluntly pointed and less attenuated (see fig. 2-25B). He included within the concept of the genus some but not all of the specimens of *Gonioloboceras eliasi* illustrated by Miller and Owen (1939, pl. 17, figs. 7-11, *non* figs. 6, 12, 13). Nassichuk also suggested that perhaps some of the *Gonioloboceras* recovered from the Wewoka Formation (Desmoinesian) as illustrated by Unklesbay (1962, pl. 7, fig. 12) in Oklahoma may be representatives of *Gonioloboceratoides*.

In regard to *Gonioloboceras* at the species level, Furnish and Glenister (1971, p. 303) stated "There may be a number of recognizable species of *Gonioloboceras* from the Midcontinent Upper Pennsylvanian, but at present there is no sound basis for differentiation of all those that have been proposed." Sims (1987) concluded that *G. goniolobum* is quite variable and that only one species exists. The Ohio specimens did not contribute significantly to the answer because all but one of the specimens are juvenile or crushed.

Miller and Downs (1950) recognized only *Gonioloboceras goniolobum* and *G. eliasi* as being legitimate, and that *G. bridgeportense* Plummer & Scott, 1937, which they did not study, may also be a distinct species. Considering Nassichuk's (1975) generic redesignation of the holotype and most but not all of the topotypes of *G. eliasi*, the remaining specimens illustrated by Miller and Owen (1939, pl. 27, figs. 6, 12, 13) should be studied to determine their specific identity. That these specimens belong in *Gonioloboceras* seems reasonable. Because these specimens are distinctly older than any other species of *Gonioloboceras*, they may be a distinct undescribed species and are referred to as *Gonioloboceras* sp. in this report.

Gonioloboceras schmidti Elias, 1962 presents additional problems in that this taxon was erected on the basis of sutural spacing. We agree with Furnish and Glenister (1971, p. 303) that this method of recognizing species in ammonoids is almost certainly not a sound primary taxonomic criterion. Septal spacing most probably is related to growth of the animal and probably varies considerably depending on the health of the individual, availability of food, and other ecological factors. However, additional study of the types of *G. schmidti* together with the other proposed species of this genus will be necessary to determine the validity of this taxon. Thus, we currently accept the validity of *G. schmidti* with strong reservations.

With these reservations in mind, the following species of *Gonioloboceras* are tentatively identified as being valid:

G. goniolobum (Meek, 1877)
G. parrishi (Miller & Gurley, 1896)
G. welleri Smith, 1903 (in part, from Illinois)
G. bridgeportense Plummer & Scott, 1937
G. schmidti Elias, 1962
Gonioloboceras sp. (formerly *G. eliasi* Miller & Owen, 1939 but holotype now assigned to *Gonioloboceratoides*)

The majority of these reported species have unstudied ontogenies. Because most of the Ohio specimens are relatively immature or crushed, we have elected to assign these specimens to *Gonioloboceras* cf. *G. goniolobum*, ?*Gonioloboceras* sp., and *Gonioloboceras* sp. with reservations.

Geologic and geographic range.—With the correct separation of *Mescalites* to Permian strata by Furnish and Glenister (1971), *Gonioloboceras* is restricted to Middle to Upper Pennsylvanian strata in North America. The only representative of the genus outside North America was identified by Delépine (1941, pl. 7, figs. 22, 23) from Morocco as *Gonioloboceras* cf. *G. eliasi* from lower Westphalian strata. Proper generic assignment of Delépine's material and the Oklahoma specimen illustrated by Unklesbay (1962) must await additional study, although Nassichuk (1975) suggests that both of these specimens belong to *Gonioloboceratoides*. The two species of *Gonioloboceras* reported by Librovich (1940) from the Lower Carboniferous of Kazakhstan almost certainly belong to somewhat homeomorphic Mississippian genera such as *Eumorphoceras* or *Girtyoceras*. Thus, *Gonioloboceras* is probably endemic to North America.

Gonioloboceras cf. *G. goniolobum* (Meek, 1877)
Pl. 2-2, fig. 2

Goniatites goniolobus Meek, 1877, p. 98-99, pl. 9, figs. 5-5b.
Gonioloboceras bicanaliculatum Smith, 1938, p. 23-24, pl. 2, figs. 4, 5.
Gonioloboceras goniolobum Miller & Downs, 1950, p. 196-200, text-fig. 3A, pl. 31, fig. 9, pl. 32, figs. 5-9 (see Miller and Downs, 1950, for an extensive synonymy to this date); Miller, Furnish & Schindewolf, 1957, p. L60, text-fig. 79; Beghtel, 1962, p. 185-189, pl. 5, fig. 9, text-figs. 21B-D, 22A; Unklesbay, 1962, p. 67-68, pl. 7, fig. 12; Windle, 1970, p. 118-119, pl. 5, fig. 11.

Diagnosis.—Conch discoidal, umbilicus relatively small. Venter relatively broad and rounded. Sculpture fine and sinuous. Suture having narrowly rounded ventral and lateral lobes; first lateral saddle angular.

Material.—*Gonioloboceras* cf. *G. goniolobum* is represented in the Ohio collections by one specimen (OSU 30709, D est. = 30.0 mm) that is laterally flattened, although portions of the sutural configuration are preserved.

Description.—Despite being laterally crushed, specimen retains poorly preserved traces of test and a partial suture. Conch proportions cannot be accurately determined; estimated diameter of 30.0 mm at best a rough estimate. Sutural configuration at crest of venter destroyed by crushing, as well as majority of lateral lobe and umbilical area. Ventral prong and first lateral saddle reasonably well preserved, although some distortion present; ventral prong narrowly rounded and first lateral saddle angular (fig. 2-25A).

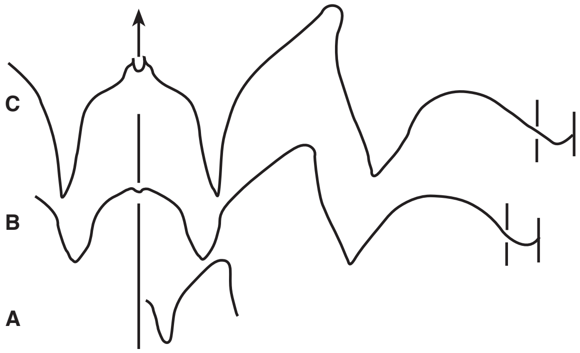

FIGURE 2-25.—Sutural outlines of *Gonioloboceras* and *Gonioloboceratoides*.
A, *Gonioloboceras* cf. *G. goniolobum* (Meek) at estimated diameter of 30 mm. Brush Creek unit, loc. Cw-1; OSU 30709.
B, *Gonioloboceratoides eliasi* (Miller & Owen) at estimated diameter of 50 mm. Cherokee beds, southern Iowa; SUI 36318.
C, *Gonioloboceras goniolobum* at diameter of 65 mm. Finis Shale Member of Graham Formation, approximately 3.5 miles (4.6 km) south of Jacksonboro, Texas; SUI 17035. Redrawn from Beghtel (1962, text-fig. 21D).

Remarks.—Comparison of the Ohio specimen of *Gonioloboceras* with other species of *Gonioloboceras* (see pl. 2, fig. 1, for a Midcontinent example) is almost impossible because of the lack of ontogenetic study this genus has received and because most species-level variation appears to be restricted to sutural differences on the venter and lateral portions of the conch. The Ohio specimen (OSU 30709) lacks most of these diagnostic parts of the suture. For comparative purposes, sutural diagrams of *Gonioloboceratoides eliasi* and *Gonioloboceras goniolobum* are presented in figures 2-25B and 2-25C. Despite the probable differences in sutural ontogeny between the Ohio specimen (D est. = 30.0 mm), *G. eliasi* (D est. = 50.0 mm), and *G. goniolobum* (D est. = 65.0 mm), we believe that the ventral prong on the Ohio specimen is more closely similar to that of *G. goniolobum*. Thus, we have placed this specimen in that taxon with reservation.

Occurrence.—1 specimen; Brush Creek unit: loc. Cw-1.

Repository.—OSU 30709.

?*Gonioloboceras* sp.
Pl. 2-7, fig. 6

Diagnosis.—Juvenile conch (D = 7.0 mm) having relatively wide, ribbed umbilicus (U max/D = 0.29) and sinuous ornament.

Material.—?*Gonioloboceras* sp. is represented in the Ohio collections by a partial, uncrushed specimen (OSU 30823) and a laterally crushed specimen (OSU 15062). Both are juveniles.

Description.—Specimen OSU 30823 preserving traces of test and growth lines indicating presence of shallow hyponomic and ocular sinuses. Distinct ribbing present on earliest exposed portions of conch and becoming less distinct at orad end of body chamber. Specimen is mostly body chamber with one well-preserved sinuous constriction. Internal whorls recrystallized; no sutures exposed. Conch dimensions and ratios: D = 7.0 mm, W = 3.2 mm, H = 3.3 mm, Umax = 2.0 mm, Umax/D = 0.29, H/D = 0.47, W/D = 0.45, H/W = 1.03. Specimen OSU 15062 having a crushed diameter of about 4.0 mm, three growth constrictions, and umbilical nodes on lateral and umbilical portions of conch. No sutures exposed.

Remarks.—Both Ohio specimens (OSU 15062 and 30823) are similar in conch proportions and ornamentation to similar-sized material (approximately 200 specimens) of *G. goniolobum* from Missourian strata in Texas. However, Beghtel (1962) observed that juvenile specimens of *Gonioloboceras* are virtually indistinguishable from immature specimens of the lower Permian taxon *Mescalites* and the Middle Pennsylvanian (Desmoinesian) homeomorphic genus *Gonioglyphioceras*. In addition, both *Gonioglyphioceras* and *Gonioloboceras* are thought to co-occur in several localities in the Midcontinent. On the basis of fusulinid correlations and brachiopod associations, the Portersville shale, which yielded specimen OSU 30823, correlates with approximately middle Missourian strata on the Midcontinent, and the Brush Creek unit, which yielded specimen OSU 15062, correlates with the lower Missourian (Sturgeon and Hoare, 1968, table 3). Thus, on the basis of correlation of the Portersville and Brush Creek units and the currently known age ranges of *Gonioloboceras*, *Gonioglyphioceras*, and *Mescalites* in the Midcontinent, both Ohio specimens are tentatively identified as *Gonioloboceras*. A species assignment is not possible at this time.

Occurrence.—2 specimens total; Portersville unit: 1 specimen from loc. Gwe-2; Brush Creek unit: 1 specimen from loc. Ad-49.

Repository.—OSU 15062, 30823.

Gonioloboceras sp.
Pl. 2-7, figs. 7, 8

Diagnosis.—*Gonioloboceras* having moderately wide, pointed prongs of ventral lobe.

Material.—A single specimen in the Ohio collection is referrable to this taxon. The specimen is a relatively mature, uncrushed internal mold.

Description.—Conch exhibiting typical *Gonioloboceras* sutural configuration; dimensions and proportions: D (est.) = 45.0 mm, Umax = 5.3 mm, Umin = 4.0 mm, H (est.) = 23.0 mm, W = 18.9 mm, Umax/D = 0.12, H/D = 0.51, W/D = 0.42, H/W = 1.22. Sutural configuration having a broad ventral lobe; prongs of ventral lobe moderately wide, slightly asymmetrical, and bluntly pointed. Slight inflection suggesting development of an adventitious lobe present adjacent to siphuncle. Lateral saddle angular and bluntly pointed, and lateral lobe slightly asymmetrical and pointed (fig. 2-26).

Remarks.—On the basis of the sutural configuration seen in *Gonioloboceratoides eliasi* (fig. 2-25B) and *Gonioloboceras goniolobum* (fig. 2-25C), this Ohio specimen (fig. 2-26) combines some of the characteristics of each genus. The slight inflection of the suture adjacent to the siphuncle is similar to that reported by Miller and Downs (1950, text-fig. 3A), Elias (1962, pl. 4, figs. 2, 4, 5, 7, 8, 11), and others as representative of sutures in species of *Gonioloboceras*. The width of the ventral lobe on the Ohio specimen is not as great as those of *Gonioloboceratoides curvatus* Nassichuk (1975, text-fig. 27) and *Gonioloboceratoides eliasi* (Miller and Owen, 1939, text-fig. 7B); however, this lobe on the Ohio specimen is definitely wider than that of *Gonioloboceras*. The lateral saddle and lateral lobe vary in minor details but are relatively similar in both genera and the Ohio specimen.

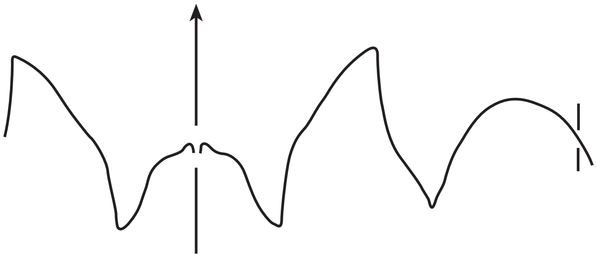

FIGURE 2-26.—Sutural outline of specimen of *Gonioloboceras* sp. at estimated diameter of 39.8 mm. Brush Creek unit, loc. Cfr-1; SUI 11047.

Because of the similarities and differences expressed in the sutural configuration of the Ohio specimen, *Gonioloboceras*, and *Gonioloboceratoides*, we recommend a restudy of the taxa assigned to these genera before a species assignment is made for the Ohio specimen. Thus, we have placed this Ohio specimen in *Gonioloboceras* with reservation.

Occurrence.—1 specimen; Brush Creek unit: loc. Cfr-1.

Repository.—SUI 11047.

Genus *Glaphyrites* Ruzhencev, 1936

Type species: *Gastrioceras modestum* Böse, 1917, p. 83-85, pl. 2, figs. 4-27; OD

Diagnosis.—A complete diagnosis separating *Glaphyrites* and *Eoasianites* Ruzhencev, 1933 is not possible at this time. The major difference is the absence of umbilical ribs or nodes in the early ontogeny of *Glaphyrites*.

Remarks.—Considerable confusion exists among North American Paleozoic ammonoid workers regarding the generic-level morphological characteristics that separate *Glaphyrites*, *Eoasianites*, and other similar-appearing genera. Taxa belonging to these genera and the similar- appearing *Syngastrioceras* Librovich, 1938, *Neogastrioceras* Nassichuk, 1975, and even *Cravenoceras* Bisat, 1928 have not been subjected to extensive analysis. It is apparent from examination of the literature on Pennsylvanian ammonoids published in the last 50 years that Russian and North American workers are in strong disagreement about the familial composition, diagnostic characteristics at the generic level, and number of species within each genus. The following are some of the more significant reports on these genera: McCaleb (1968), Gordon (1964), Nassichuk (1975), and Ruzhencev and Bogoslovskaya (1971, 1978). It should be noted that *Neoicoceras* Hyatt, 1900 has an evolute conch similar to one of the Ohio specimens. *Neoicoceras* was a poorly known form from lower Pennsylvanian strata until Furnish and Knapp (1966) redescribed the single specimen that has served as type for the genus. Less than 10 years later, Nassichuk (1975) described a new species of *Neoicoceras* from the Canadian

Arctic. In his report, Nassichuk recognized three taxa as belonging in *Neoicoceras*: the original type of the genus, *N. elkhornense* (Miller & Gurley, 1896); *N. martini*, which Nassichuk described in 1975; and *N. walkeri* (Webster & Lane, 1967) from Chesterian strata in Nevada. We have looked at the types of these species, and we agree that *N. martini* is a valid member of the genus *Neoicoceras*. However, we would retain the Nevada specimens described by Webster and Lane in *Syngastrioceras* because of the greater conch width. This assignment suggests that the ammonoid fauna from Nevada is more Lower Pennsylvanian in aspect than Upper Mississippian.

Overall, the evolute conch form exhibited by *Syngastrioceras walkeri* can be found in varying degrees throughout the Pennsylvanian succession in North America. Reinvestigation of these forms, which typically are placed in *Eoasianites*, is needed before a reasonable taxonomic judgment can be made on the evolute Ohio specimens. This need is especially true because only five moderately well preserved specimens referable to this generic complex have been recovered from the Ohio marine stratigraphic succession. It is clearly beyond the scope of this report to resolve the generic-level confusion within the family Neoicoceratidae. For descriptive purposes, we have placed the Ohio specimens in *Glaphyrites*. Two species appear to be present, and we have attempted to assign them to previously described North American taxa.

Geologic and geographic range.—Ruzhencev (1962) gave the geologic range of *Glaphyrites* as Lower Carboniferous to Lower Permian and indicated that a good number of species are present in the Urals, Verkhoyansk, and North America. We are not prepared to redefine this age range or occurrence because of the taxonomic confusion.

Glaphyrites cf. *G. anguloumbilicatus* Plummer & Scott, 1937
Pl. 2-7, figs. 10, 11, 14

Eoasianites cf. *E. globulosus* (Meek & Worthen, 1860); Miller & Sturgeon, 1946, p. 385-386 (part), pl. 56, figs. 10, 11.

Diagnosis.—Conch evolute; juvenile (D = 30.2 mm) sutural configuration having inflated, moderately attenuated prongs of ventral lobe, rounded lateral saddle, symmetrical and inflated lateral lobe, and V-shaped umbilical lobe symmetrically placed between umbilical shoulder and seam.

Material.—*Glaphyrites* cf. *G. anguloumbilicatus* is represented in the Ohio collections by a nontestiferous, incomplete, slightly distorted phragmocone and a nonseptate, moderately distorted, testiferous conch.

Description.—Conch evolute, umbilicus wide. Conch measurements and proportions for juvenile specimen OSU 18735: D = 30.2 mm, H = 6.0 mm, W (est.) = 27.4 mm, Umax = 19.0 mm, Umin = 13.2 mm, Umax/D = 0.63, H/D = 0.20, W/D = 0.91, H/W = 0.22. Estimated measurements for specimen OSU 30829: D = 63.0 mm, Umax = 37.0 mm, Umin = 30.5 mm, H = 21.0 mm, W = 40.0 mm, Umax/D = 0.59, H/D = 0.33, W/D = 0.63, H/W = 0.53. Test on larger specimen mostly covered by remnants of dorsal shell, which retains some traces of internal suture. Growth lines not preserved; however, pronounced ridge present at position of umbilical shoulder. On outer three whorls shoulder barren of ornament; however, on some earlier volutions traces of longitudinal ornament preserved on ridge. Sutural configuration well displayed on juvenile specimen (fig. 2-27). Median saddle between prongs of ventral lobe about one-half the height of rounded lateral saddle. Prongs of ventral lobe shorter than lateral lobe but both inflated, symmetrical, and moderately attenuated. Umbilical lobe V shaped and located between umbilical saddle and seam. Internal suture exposed on larger specimen is too distorted for an accurate sutural diagram; however, both the dorsal and dorsolateral lobes clearly are slightly inflated and quite attenuated.

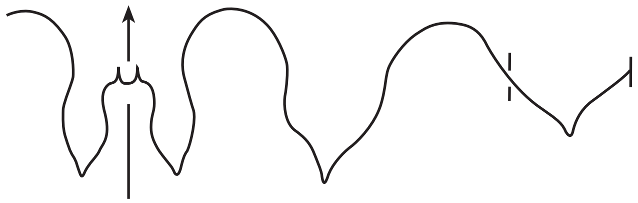

FIGURE 2-27.—Sutural outline of specimen of Glaphyrites cf. G. anguloumbilicatus Plummer & Scott at estimated diameter of 27 mm. Putnam Hill unit, loc. Mc-1; OSU 18735.

Remarks.—We have placed these specimens in *Glaphyrites* cf. *G. anguloumbilicatus* with reservations, as restudy of this taxon is desirable. The conchs of all the species assigned to *Glaphyrites* (and all the other genera listed in the Remarks section of this genus) are markedly evolute in the early juvenile stages but become, to varying degrees, more involute at large diameters. The Ohio specimens appear to be one of the more evolute species of the genus and seem to be somewhat comparable in cross section to the specimen illustrated by Plummer and Scott (1937, pl. 15, fig. 9). Other species that have been illustrated are slightly different from the Ohio specimens. Beghtel (1962, p. 210, text-fig. 25F) indicated that the umbilical lobe on *Eoasianites* (*sensu* Beghtel) *angulatus* (Girty, 1915) is placed near the umbilical shoulder. Also, the specimens he illustrates as *Eoasianites excelsus* (Meek, 1876) and *E. hyattianus* (Girty, 1915) have more involute, less compressed conchs than the Ohio specimens. *Glaphyrites* (*sensu* this report) *jonesi* (Miller & Owen, 1937) has a wider conch and more splayed prongs of the ventral lobe. Overall, these two Ohio specimens seem to be somewhat unique, and when studies of the described species of this genus are complete, these specimens may deserve recognition as a distinct species.

Occurrence.—2 specimens total; Washingtonville unit: 1 specimen from loc. Tc-1; Putnam Hill unit: 1 specimen from loc. Mc-1.

Repository.—OSU 18735, 30829.

Glaphyrites jonesi (Miller & Owen, 1937)
Pl. 2-4, figs. 5, 9; pl. 2-7, figs. 12, 13, 16

Gastrioceras jonesi Miller & Owen, 1937, p. 413-415, pl. 51, figs. 1-3, 10, text-fig. 3, table 1 (part).

Diagnosis.—Conch evolute during early ontogeny (D = 25.0+ mm), width increasing as diameter increases, height relatively low. Prongs of ventral lobe moderately attenuated, median saddle located at about one-half the height of horseshoe-shaped lateral saddle. Lateral lobe slightly inflated and symmetrical. Umbilical lobe located almost midway between umbilical shoulder and seam.

Material.—*Glaphyrites jonesi* is represented in the collections by three reasonably complete juvenile phragmocones.

Description.—Conch evolute, whorl section markedly wide and depressed. Conch measurements and proportions given in table 2-9. Ornament limited to umbilical shoulder, as poorly preserved dorsal shell covers venter. Specimen OSU 48946 (pl. 2-4, fig. 9) possessing conspicuous umbilical ridge bearing both longitudinal and transverse lirae, interaction of lirae producing a riblike appearance which is not duplicated on internal mold of conch. Suture having attenuated, slightly splayed prongs of ventral lobe and median saddle located at about one-half the height of rounded, horseshoe-shaped lateral saddle. Lateral lobe symmetrical and slightly inflated. Umbilical saddle widely rounded. Bluntly V-shaped umbilical lobe located nearly symmetrically between umbilical shoulder and seam (figs. 2-28A, B).

Remarks.—A topotype of *G. jonesi* (SUI 50969, fig. 2-28C) from Oklahoma has been compared directly with the Ohio specimens Both the topotype and the Ohio hypotypes have essentially the same conch form, except the topotype is somewhat wider (see table 2-9). Some slight sutural differences also can be detected. The topotype of *G. jonesi* has less attenuated prongs of the ventral lobe and a wider, more U-shaped lateral saddle at equivalent size. The umbilical lobe of the topotype is closer to the umbilical shoulder than is that of the Ohio specimens. When additional studies of interspecific variation are made on the holotype and the topotype of this species it is quite possible that the Ohio specimens will prove to be a distinct species from *G. jonesi* on the basis of sutural configuration and conch width.

Other species generally referable to *Glaphyrites* such as *G. anguloumbilicatus*, *G. angulatus*, *G. excelsus*, and *G. hyattianus* are distinguishable from *G. jonesi* on the basis of conch shape. None of these species has the evolute, depressed whorls seen in *G. jonesi*.

Occurrence.—3 specimens; Washingtonville unit: loc. CAr-2.

Repository.— Hypotypes OSU 30800, 30808, 48946; topotype SUI 50969.

Genus *Aktubites* Ruzhencev, 1955

Type species: *Aktubites trifidus* Ruzhencev, 1955, p. 1108-1110, fig. 1; OD

TABLE 2-9.—*Conch measurements and ratios of* Glaphyrites jonesi *from the Washingtonville unit in Ohio and the upper Holdenville Formation in Oklahoma (SUI specimen)*

Specimen	D (mm)	Umax (mm)	Umin (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
OSU 48946 (hypotype)	19.0^1	17.7^1		4.0^1	17.5^1	0.90	0.21	0.92	0.23
OSU 30800 (hypotype)	14.1	10.0		3.9^1	12.2^1	0.71	0.28	0.87	0.32
OSU 30808 (hypotype)	19.7^1	13.2^1		5.5	17.1	0.67	0.28	0.87	0.32
SUI 50969 (topotype)	23.3	14.1	10.3	4.1	24.0	0.61	0.18	1.03	0.17

^{1}Estimate.

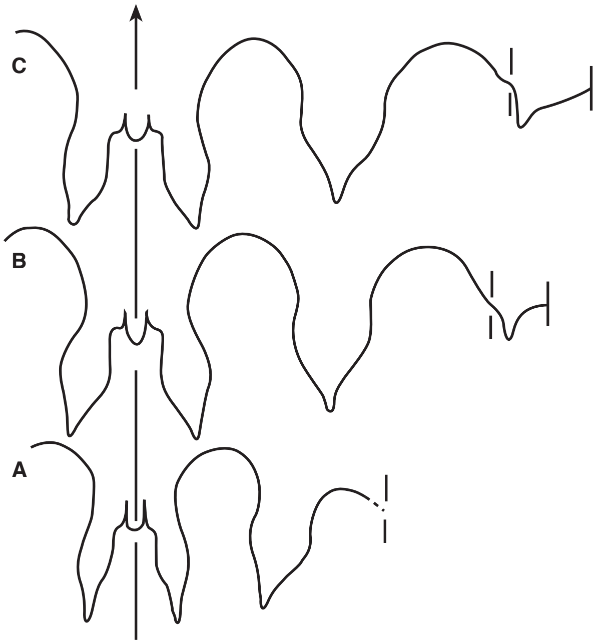

FIGURE 2-28.—Sutural outlines of two hypotypes and a topotype of *Glaphyrites jonesi* (Miller & Owen).

A, **B**, hypotypes at estimated diameters of 15.8 mm (**A**) and 19.8 mm (**B**). Washingtonville unit, loc. CAr-2; OSU 48946 (**A**) and OSU 30808 (**B**).

C, topotype at diameter of 19.0 mm. Upper Holdenville Formation (formerly considered to be the Seminole Formation), Oklahoma; SUI 50969.

Diagnosis.—Conch subglobose, umbilicus medium sized. Sutural formula = $(V_1V_1)(L_2L_1L_2)U{:}(l_2l_1l_2)(D_2D_1D_2)$. Ventral lobe shorter than middle prong (L_1) of lateral lobe. Secondary lateral, dorsolateral, and dorsal lobes being distinct sutural elements that are generally symmetrical.

Remarks.—According to Ruzhencev (1955), *Aktubites* represents the earliest occurrence of the family Shumarditidae. In the same report, he divided this genus into two subgenera, *Aktubites* (*Aktubites*) and *Aktubites* (*Postaktubites*), the latter subgenus having as its type *Shumardites cuyleri* Plummer & Scott, 1937. In 1960, Popov described *Shumardites (Eoshumardites) lenensis*. Ruzhencev (1962) indicated that *S.* (*E.*) *lenensis* was a junior synonym of *Aktubites*. However, in 1978, Ruzhencev and Bogoslovskaya, under their discussion of the family Shumarditidae, recognized *Eoshumardites* as a distinct genus on a lateral branch of the main family. In 1994, Boardman, Work, and Mapes revised the family Shumarditidae and placed *Aktubites* in the family Parashumarditidae.

In our opinion, *Aktubites* is a valid genus that differs from *Shumardites* Smith, 1903 by having distinct, generally symmetrical secondary lateral-, dorsolateral-, and dorsal-lobe elements. These sutural elements in *Shumardites* develop a marked asymmetry. *Eoshumardites* can be distinguished from *Aktubites* by the length of the L_1 element that extends below the prongs of the ventral lobe for almost one-third of its length.

In regard to the subgenus *Aktubites* (*Postaktubites*) that was recognized by Ruzhencev (1955, 1962), we have examined the holotype of *Shumardites cuyleri* and determined that excessive removal of test has somewhat altered the lateral-lobe configuration and thereby influenced the sutural diagrams published by several workers, including Plummer and Scott (1937, text-fig. 61C) and Miller and Sturgeon (1946, text-fig. 2b). Examination of 17 more recently collected topotypes and/or hypotypes indicates that this taxon develops asymmetrical secondary lateral-lobe elements at diameters of about 50.0 mm. The prongs of the ventral lobe on juvenile conchs (D est. = 10.0 mm) are simple, slightly inflated, and only slightly asymmetrical. On the basis of these sutural details, we would retain *S. cuyleri* in *Shumardites* and suppress the concept of subgenera in *Aktubites*. For a more extensive discussion of *Aktubites* and its stratigraphic position and phylogeny see Boardman, Work, and Mapes (1994).

Geologic and geographic range.—Aktubites trifidus was reported from Middle Carboniferous units in the Urals. Later, Ruzhencev and Bogoslovskaya (1978) indicated that the genus arose near the ?Moscovian/Zhigulian boundary. On the basis of its occurrence in the Appalachian Basin in Ohio, it appears that *Aktubites* arose relatively early in the Desmoinesian rather than at the ?Moscovian/Zhigulian boundary. This report of *Aktubites* from Ohio constitutes the first known occurrence of the genus in North America.

Aktubites trifidus Ruzhencev, 1955
Pl. 2-4, figs. 8, 10

Aktubites trifidus Ruzhencev, 1955, p. 1108-1110, text-fig. 1.
Neoshumardites sp. (Ruzhencev, 1936) Miller & Sturgeon, 1946, p. 386-387, pl. 56, fig. 12, text-fig. 2b.

Diagnosis.—Aktubites having highly inflated asymmetrical prongs of ventral lobe; lateral saddle symmetrical and subangular; secondary lobes on primary lateral lobe distinct, rounded, and symmetrical; dorsolateral lobe distinctly trifid (three lobed) and only moderately asymmetrical.

Material.—Aktubites trifidus is represented in the Ohio collections by 13 specimens; nine are laterally crushed and the assignment to the genus is based on the sutural configuration of the dorsolateral lobe. The remaining four specimens are more-or-less complete internal molds of phragmocones. It is on these four specimens that we base our description.

Description.—Conch subglobose and umbilicus moderate sized. Conch measurements and proportions given in table 2-10. Ornament and growth lines of test covered by dorsal shell and cannot be determined. Suture (fig. 2-29) having inflated, somewhat attenuated, markedly asymmetrical prongs of ventral lobe; prongs separated by median saddle, which is about one-half the length of symmetrical, subangular lateral saddle. Lateral lobe having well-developed, symmetrical, rounded secondary lobes and extending approximately one-third its length below prongs of ventral lobe. Umbilical saddle broadly rounded. Umbilical lobe compressed, V shaped, having bluntly rounded tip, and located relatively near umbilical shoulder. Primary dorsolateral lobe having two moderately asymmetrical secondary lobes. Dorsal lobe also having two secondary lobes but is symmetrical.

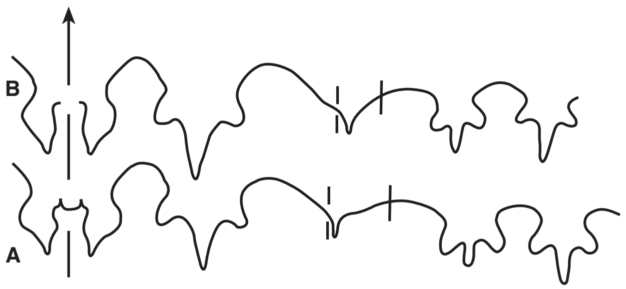

FIGURE 2-29.—Sutural outlines of two hypotypes of Aktubites trifidus Ruzhencev from the Putnam Hill unit.
A, at estimated diameter of 8.0 mm. Loc. Ty-3; OSU 30807.
B, at diameter of 10.2 mm. Loc. Mc-2; OSU 30723.

Remarks.—Both the conch proportions and the figured sutural diagram presented by Ruzhencev (1955) compare favorably with the Ohio specimens. Thus, we consider the Ohio specimens to be conspecific with the described types of *Aktubites trifidus* from the former Soviet Union.

On the basis of associated ammonoid fauna (that is, *Mangeroceras canfieldense*, *Eoschistoceras* sp., *Gastrioceras* sp., *Gonioglyphioceras* sp. A, and *Wellerites* cf. *W. mohri*), we consider the Putnam Hill unit to be probably early Demoinesian in age. Because the Ohio specimens and the Russian specimens are conspecific, we believe it likely that the Russian occurrence is of early Desmoinesian age rather than ?late Desmoinesian/early Missourian (=?Late Moscovian/Zhigulian sensu Ruzhencev and Bogoslovskaya, 1978).

It should be noted that Miller and Sturgeon (1946) recognized the unique nature of this taxon; however, they elected to leave it unnamed because of the poor quality of the single available specimen at that time. Since their 1946 report, detailed field work by Sturgeon indicates the ammonoid- bearing unit is the Putnam Hill unit, rather than the Vanport unit.

Occurrence.—13 specimens total; Putnam Hill unit: 5 specimens from loc. Mc-2; 4 specimens from loc. Ms-3; 2 specimens from loc. Td-4; 1 specimen each from locs. Mg-4 and Ty-3.

Repository.—Hypotypes, OSU 18737, 30722 to 30724, 30807, 30824 to 30828.

TABLE 2-10.—*Conch measurements and ratios of* Aktubites trifidus *from the Putnam Hill unit in Ohio*

Specimen	D (mm)	Umax (mm)	Umin (mm)	H (mm)	W (mm)	Umax/D	H/D	W/D	H/W
OSU 30723 (hypotype)	11.1	5.1	4.0	2.9	8.6	0.46	0.26	0.77	0.34
OSU 30724 (hypotype)	16.0	8.8	5.8	4.8	11.4	0.55	0.30	0.71	0.42
OSU 30827 (hypotype)	13.8[1]			3.8[1]	8.0[1]		0.28	0.38	0.48

[1] Estimate.

Genus *Kargalites* Ruzhencev, 1938

Type species: *Marathonites timorensis* Haniel var. *typica*
Ruzhencev 1933, p. 174-175; OD

Remarks.—Ruzhencev and Bogoslovskaya (1978) include three subfamilies in the family Marathonitidae—the Kargalitinae, the Marathonitinae, and the Peritrochiinae. Most of the genera and species within the family are based on Permian material. The Carboniferous specimens from North America have been treated in a variety of ways by various authors. Because of the overall complexity involved with the taxonomy of this family, we are certain that additional specimens in our undescribed collections (more than 700 specimens from the Middle and Upper Pennsylvanian strata in the Midcontinent of North America) will substantially alter the overall concept of the familial phylogeny for taxa occurring in the Pennsylvanian. Thus, we consider it prudent not to give a diagnosis for this genus at this time. Our generic assignment of the single, poorly preserved Ohio specimen is made for convenience; we are certain, however, that this specimen belongs in this family. With this in mind, it seems appropriate not to give a geologic range or distribution for the genus.

Kargalites sp.
Pl. 2-7, fig. 15

Material.—A single specimen in the Ohio collection is referred to this taxon. The specimen is a partly complete, distorted, nontestiferous internal mold in a sandy limonitic matrix. Only the internal portion of the conch can be discerned.

Description.—Conch configuration uncertain, although partly complete whorls suggest a globose, involute conch having a small umbilical opening (U est. = 2.0 mm). Conch diameter estimated at 11.0 mm. Internal suture (D_1, D_2, I_2, I_1, I_2, and U_2 elements; fig. 2-30) visible. D_1 element symmetrical and attenuated; D_2 element bifid at tip and slightly asymmetrical. I_1 element markedly asymmetrical, I_2 elements more symmetrical and bifid at tips. U_2 element not subdivided.

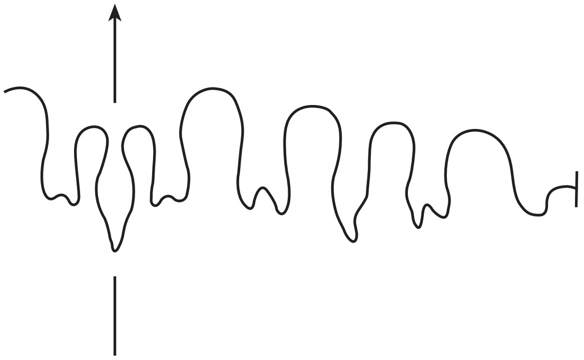

FIGURE 2-30.—Sutural outline of internal suture of *Kargalites* sp. at estimated diameter of 12.0 mm. Portersville unit, loc. CAc-2; SUI 11046.

Remarks.—Relatively few internal sutures have been published for taxa of this family. A review of the published Permian and Pennsylvanian literature (Böse, 1917; Miller and Downs, 1950; Plummer and Scott, 1937; Ruzhencev, 1956b; and numerous other references) has failed to locate a representative internal suture similar to the Ohio specimen. Such a situation is not surprising, as many of the described taxa of this family have not had their internal sutural configuration documented. Thus, the Ohio specimen is assigned to *Kargalites* with reservation.

Occurrence.—1 specimen; Portersville unit: loc. CAc-2.

Repository.—SUI 11046.

INDETERMINATE GENERA AND SPECIES OF OHIO AMMONOIDS

Not surprisingly, in the course of evaluating the available Pennsylvanian ammonoid cephalopods from Ohio, we found a number of specimens that cannot be identified to family or lower levels. In most cases the specimens are too poorly preserved to allow even a reasonable guess as to their identification. In other cases, the specimens are exceptionally well preserved, but are so juvenile that distinguishing characteristics are not present. The following descriptions provide what data are available for these specimens in the hope that future workers will be able to obtain better specimens for study. The specimens are listed by stratigraphic unit and locality.

Putnam Hill-Vanport units undifferentiated, locality Tsc-1

OSU 30809.—This specimen is a well-preserved, pyritized, nearly complete internal mold of a juvenile conch. The conch is markedly involute and the umbilicus is a pinpoint; D = 3.8 mm, W = 2.5 mm, and H = 2.1 mm. Growth lines preserved on the internal mold are transverse and slightly sinuous; several longitudinal lirae are present on the venter. The suture (fig. 2-31) has symmetrical, pointed prongs of the ventral lobe, a rounded lateral saddle, and a widely V-shaped, bluntly pointed lateral lobe. The umbilical lobe is broadly U shaped.

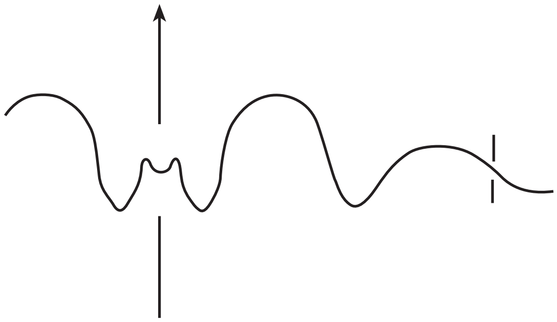

FIGURE 2-31.—Sutural outline of unidentified ammonoid at estimated diameter of 3.8 mm. Putnam Hill-Vanport units undifferentiated, loc. Tsc-1; OSU 30809.

OSU 30840.—Included under this repository number are 10 generally well preserved pyritized juveniles. Two distinct forms appear to be present.

Lower Mercer unit, locality MUje-1

OSU 30810.—This specimen (pl. 2-7, fig. 9) is a portion of a septate whorl that does not preserve the umbilical area. The conch of the specimen is moderately globose; estimated diameter is 9.0 mm and width is about 7.5 mm. No ornament is preserved. The suture has nearly symmetrical, U-shaped prongs of the ventral lobe. The lateral saddle is wide and U shaped, and the lateral lobe is symmetrical, V shaped, and bluntly pointed (fig. 2-32).

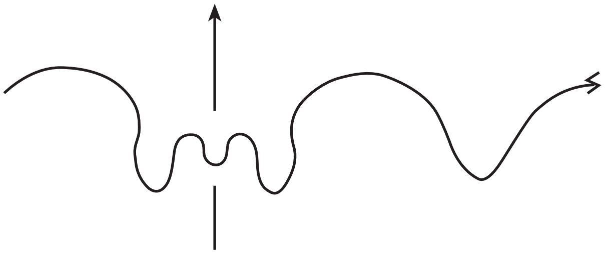

FIGURE 2-32.—Sutural outline of unidentified ammonoid at estimated diameter of 8.0 mm. Lower Mercer unit, loc. MUje-1; OSU 30810.

OSU 30811.—This specimen has several whorls that are visible despite extreme lateral crushing of the conch. The conch is ribbed in the umbilical region. Estimated measurements are D = 9.0 mm and Umax = 3.7 mm. There are three constrictions on the last whorl. No sutures or growth lines are exposed, although the constrictions are sinuous and have a moderate ventral sinus.

OSU 30812.—This specimen is a laterally crushed body chamber. Approximately one-half whorl is preserved. The umbilical opening is relatively small; faint umbilical nodes are present. Conch measurements of the crushed specimen are D = 13 mm and Umax = 4 mm.

OSU 30813.—This specimen is a fragment of the ventral portion of a body chamber. The single growth constriction present has a slight ventral salient.

OSU 30830.—This specimen is a laterally crushed body chamber. Diameter of the crushed conch is 4.0 mm and diameter of the umbilical opening is <0.5 mm. The aperture appears to be intact and forms a part of a ventral sinus and a shallow but complete ocular sinus.

Lowellville (Poverty Run) unit, locality Tfr-1

OSU 30831.—Included under this repository number are 71 juvenile specimens of unidentified Ohio ammonoid cephalopods less than 2 mm in diameter. Two distinct conch forms are present. One group of specimens has a moderately evolute conch, a relatively wide umbilicus, and low-relief umbilical nodes around the umbilicus. The other group has a more moderately involute conch and a relatively small umbilicus. Eight-lobed sutural configurations are present on several specimens in each group.

OSU 30832.—This specimen is a partly complete, distorted portion of a body chamber. The umbilical area is not exposed.

OSU 30833.—This specimen is a hand-sized sample of dark-gray shale containing fragments of ammonoid test in several places. The test is not ornamented, and no suture patterns are detectable.

OSU 30834.—Included under this repository number are two specimens of ammonoid cephalopods. The larger specimen is a fragment of a body chamber. The other is an incomplete phragmocone retaining umbilical nodes. This latter specimen is possibly a specimen of *Gastrioceras*.

OSU 30835.—This specimen is a laterally crushed one-half volution of a tightly umbilicate ammonoid body chamber. Diameter of the crushed conch is estimated at 14 mm; diameter of the umbilical opening is approximately 1 mm. Ornament is simple and transverse.

OSU 30836.—This specimen is a laterally crushed one-third volution of an ammonoid body chamber. The diameter of the crushed conch is estimated at 37 mm and the umbilical diameter is about 9 mm.

OSU 30837.—This specimen is a hand sample of dark-gray shale containing several fragments of possible ammonoid test.

Brush Creek unit, locality Ale-19

OSU 30839.—This specimen is a partial whorl of a pyritized juvenile. No sutures or diagnostic ornament are present.

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APPENDIX B.—AMMONOID COLLECTING LOCALITIES IN OHIO

Specimens providing the basis for this report on ammonoids came from 10 stratigraphic units at 34 localities listed below in Athens, Carroll, Columbiana, Guernsey, Mahoning, Muskingum, Stark, and Tuscarawas Counties (see fig. 2-1, p. 195). The localities are listed in numerical order under the respective counties and civil townships, which are arranged alphabetically according to county and township names. The capitalized first letter(s) of the locality designation indicates the county, the lower case letter(s) the civil township, and the number following is our file number for that particular locality in the township. Exposures are located by sections or fractions thereof, by reference to natural features or cultural landmarks present at the time of collecting, and/or by reference to nearby elevation numbers on pertinent U.S. Geological Survey 7.5-minute topographic quadrangle maps, which are indicated in capital letters. This information is followed by the name of the stratigraphic unit(s); the file number of any Ohio Division of Geological Survey (OGS) stratigraphic section(s) at or near the locality; the names of the identified genera and species, and, in parentheses, the number of specimens collected at that locality. It should be noted that most mine localities have been reclaimed and are no longer accessible for collecting. Other localities also may be inaccessible.

(Editor's note: some descriptions may now be out of date because of road and other cultural changes.)

ATHENS COUNTY:

Athens Township:

Aa-41. Exposure at cliff on east side of Ohio Rte. 56, 0.4 mile (0.65 km) south of junction of Ohio Rtes. 56 and 682, THE PLAINS. Brush Creek. OGS 12158. *Pennoceras seamani* (8).

Dover Township:

Ad-49. Exposure at steep road cut north of junction of U.S. Rte. 33 and Ohio Rte. 682 at southeast edge of Beaumont, NELSONVILLE. Brush Creek. OGS 15062. ?*Gonioloboceras* sp. (1).

Lee Township:

Ale-18. Diamond Stone Quarries, Inc., Plant No. 2 on north side of U.S. Rte. 50, NW$^{1}/_{4}$ sec. 13 and SW$^{1}/_{4}$ sec. 14, ALBANY. Brush Creek. OGS 11559. *Neoaganides grahamensis* (10).

Ale-19. Diamond Stone Quarries, Inc., Plant No. 1 east of Columbia Rd. and south of U.S. Rte. 50 along Leading Creek, N$^{1}/_{2}$NE$^{1}/_{4}$ sec. 7, ALBANY. Brush Creek. Unidentified ammonoid (1).

Ale-35. Exposures along Ohio Rte. 32 (formerly Ohio Rte. 346) (Appalachian Hwy.), secs. 13 and 19, ALBANY and VALES MILLS. Brush Creek. *Neoaganides grahamensis* (21).

CARROLL COUNTY:

Center Township:

CAc-2. Abandoned quarry (formerly operated by the Hanna Coal Co. and later by Joe Skinner), ctr. and SE$^{1}/_{4}$ sec. 14, CARROLLTON. Portersville. OGS 15462, 15569. *Kargalites* sp. (1).

Rose Township:

CAr-2. Strip mines of James Bros. Coal Co. south of Huff Run, secs. 32 and 33, MINERAL CITY. Washingtonville. OGS 15098. *Glaphyrites jonesi* (3), *Gonioglyphioceras gracile* (11), *Neoaganides grahamensis* (2), *Somoholites saundersi* (2), *Wellerites* cf. *W. mohri* (3).

COLUMBIANA COUNTY:

Center Township:

Cc-7. Exposure along tributary valley on west side of Middle Fork Little Beaver Creek and Center Twp. Rd. 200 at Coleman, W-ctr. sec. 9, LISBON. Washingtonville. *Neoaganides grahamensis* (20).

Franklin Township:

Cfr-1. Exposure in Conrail RR cut at south edge of Summitville just east of Ohio Rte. 644, NW$^{1}/_{4}$SE$^{1}/_{4}$ sec. 23, KENSINGTON. Brush Creek. OGS 14776. *Gonioloboceras* sp. (1).

Madison Township:

Cma-5. Abandoned strip mine on Harry Given farm on Southwest side of Columbiana County Rd. 424, NE$^{1}/_{4}$SW$^{1}/_{4}$ sec. 23, WEST POINT. Brush Creek. *Pennoceras seamani* (1).

Cma-8. Exposure along U.S. Rte. 30 just west of junction with Ohio Rte. 7, NE$^{1}/_{4}$SE$^{1}/_{4}$ sec. 13, WEST POINT. Brush Creek. *Paraschistoceras* sp. (1).

Perry Township:

Cp-3. Exposure at abandoned Brookwood mine (type locality for Columbiana shale) east of U.S. Rte. 62 and west of Perry Twp. Rd. 766 (Egypt Rd.), SE$^{1}/_{4}$ NW$^{1}/_{4}$ sec. 29, SALEM. Columbiana. OGS 3778. *Gonioglyphioceras columbianaense* (1), *Wellerites* cf. *W. mohri* (1).

Salem Township:

Cs-3. Spoil pile (now removed) of abandoned Delmore mine of Sterling Coal Co. on valley floor of East Branch of Middle Fork Little Beaver Creek northeast of Franklin Square and north of Ohio Rte. 344, NE$^{1}/_{4}$SW$^{1}/_{4}$ sec. 14, LISBON. Columbiana. OGS 1707. *Wellerites* cf. *W. mohri* (1).

Cs-7. Spoil pile of abandoned Bossart or Buzzard's Glory mine on west side of Middle Fork Little Beaver Creek, SW$^{1}/_{4}$NE$^{1}/_{4}$ sec. 3, SALEM. Columbiana. *Somoholites sagittarius* (1).

Cs-16. Abandoned deep mine near bend in Ohio Rte. 344 on southeast side of Middle Fork Little Beaver Creek at west edge of Franklin Square, NW$^{1}/_{4}$ sec. 22, LISBON. Columbiana. *Somoholites sagittarius* (1).

Washington Township:

Cw-1. Exposure along Tidballs Run and Ohio Rte. 164 north of Salineville, NW$^{1}/_{4}$NE$^{1}/_{4}$ sec. 24, GAVERS. Brush Creek. *Gonioloboceras* cf. *G. goniolobum* (1).

GUERNSEY COUNTY:

Adams Township:

Ga-1. Abandoned quarries on north side of Adams Twp. Rd. 413 east of road junction at elevation 934, NW$^{1}/_{4}$ sec. 24 and NE$^{1}/_{4}$ sec. 25, BLOOMFIELD. Cambridge. *Schistoceras* sp. (1).

Westland Township:

Gwe-1. Abandoned quarry of John Gress and Sons (later Ace Landfill) approx. 0.25 mile (0.4 km) east of New Concord and 0.3 mile (0.5 km) north of U.S. Rte. 40, NEW CONCORD. Cambridge. *Schistoceras* sp. (1).

Gwe-2. Abandoned strip mine in SE$^{1}/_{4}$ sec. 19 and NE$^{1}/_{4}$

sec. 22, NEW CONCORD. Portersville. ?*Gonioloboceras* sp. (1), *Neoaganides grahamensis* (1).

MAHONING COUNTY:

Berlin Township:

Mbe-1. Exposure along Mill Creek east of Bedell Rd. and Berlin Reservoir in vicinity of mouth of Turkey Broth Creek, LAKE MILTON. Lower Mercer. ?*Paralegoceras* sp. (1).

Canfield Township:

Mc-1. Abandoned strip mine on north side of U.S. Rte. 224 approx. 2.0 miles (3.2 km) west of Canfield, CANFIELD. Putnam Hill. *Glaphyrites* cf. *G. anguloumbilicatus* (1).

Mc-2. Abandoned strip mine of Leb Coal Co. on east side of Mahoning County Rd. 93 (Crory Rd.) 0.25 to 0.5 mile (0.4 to 0.8 km) south of U.S. Rte. 224, CANFIELD. Putnam Hill. *Aktubites trifidus* (5), *Gastrioceras* sp. (1), *Gonioglyphioceras* sp. A (2), *Mangeroceras canfieldense* (43), *Wellerites* cf. *W. mohri* (1).

Mc-5. Abandoned strip mine west of Canfield on north side of U.S. Rte. 224 at Mahoning County Rd. 93 (Crory Rd.), CANFIELD. Putnam Hill. *Wellerites* cf. *W. mohri* (1).

Green Township:

Mg-4. Spoil pile (no longer accessible) of abandoned Nick Weingart drift mine on northeast side of Middle Fork Little Beaver Creek, E-ctr. sec. 7, SALEM. Putnam Hill. OGS 5608. *Aktubites trifidus* (1), *Wellerites* cf. *W. mohri* (1).

Smith Township:

Ms-3. Abandoned strip mines of Keller Mines, Inc., northeast of Alliance in secs. 7, 8, 17, 18, and 19, ALLIANCE. Putnam Hill. *Aktubites trifidus* (4), ?*Eoschistoceras* sp. (1), *Mangeroceras canfieldense* (4).

MUSKINGUM COUNTY:

Jefferson Township:

MUje-1. Exposure on west side of Ohio Rte. 60 approx. 1.5 miles (2.4 km) southeast of Wakatomika Creek, DRESDEN. Lower Mercer. *Gastrioceras* sp. (2), unidentified ammonoids (5).

Union Township:

MUu-2. Exposure along tributary to Crooked Creek west of Richard Rice (later Tony Fazekas) farm buildings, on Muskingum County Rd. 65 approx. 1.5 miles (2.4 km) south of New Concord, NEW CONCORD. Ames. *Schistoceras* sp. (1).

Uncertain localities:

MUuc-2. Undescribed locality. Brush Creek. *Neoaganides grahamensis*? (3).

MUuc-6. Undescribed locality near Norwich, NORWICH. Cambridge? *Schistoceras* sp. (1).

STARK COUNTY:

Sandy Township:

Ss-4. Abandoned strip mine of D and M Coal Co., SE$^1/_4$ sec. 10, MALVERN. Columbiana. *Gonioglyphioceras columbianaense* (1).

Ss-6. Abandoned strip mine of D and M Coal Co., NE$^1/_4$ sec. 15, MALVERN. Columbiana. *Gonioglyphioceras columbianaense* (1).

TUSCARAWAS COUNTY:

Clay Township:

Tc-1. Exposures at junction of Ohio Rte. 416 (formerly Ohio Rte. 16) and Clay Twp. Rd. 196 at elevation 832 and to northwest in strip mine of High Bluff Coal Co. on northeast side of Clay Twp. Rd. 196, GNADENHUTTEN. Washingtonville. *Glaphyrites* cf. *G. anguloumbilicatus* (1).

Dover Township:

Td-4. Abandoned strip mine on Southwest side of Ohio Rte. 39, NE$^1/_4$NW$^1/_4$ sec. 2, DOVER. Putnam Hill-Vanport undifferentiated. *Aktubites trifidus* (2).

Franklin Township:

Tfr-1. Exposure on south side of Sugar Creek just below Beach City dam, W-ctr. sec. 1?, NAVARRE. Lowellville (Poverty Run). *Dimorphoceratoides campbellae* (1), *Gastrioceras* sp. (4), ?*Mangeroceras canfieldense* (1), *Phaneroceras* cf. *P. compressum* (2), unidentified ammonoids (78).

Sugar Creek Township:

Tsc-1. Abandoned strip mine of Belden Brick Co. north of Ohio Rte. 39 and east of Ohio Rte. 93 northeast of Shanesville and north of Sugarcreek, NW$^1/_4$ sec. 2 and NE$^1/_4$ sec. 3, SUGARCREEK. Putnam Hill-Vanport undifferentiated. OGS 13316. Unidentified ammonoids (11).

York Township:

Ty-3. Exposures in abandoned strip mine (formerly a borrow pit) of Zoar Mining Co. on east side of I-77 and east of Stone Creek, NW$^1/_4$ sec. 17, NEW PHILADELPHIA. Putnam Hill. *Aktubites trifidus* (1), *Gastrioceras* sp. (1).

PLATE 2-1

FIGURES 1, 3, 4, 8, 10, 12, 14. *Mangeroceras canfieldense* Sturgeon, Windle, Mapes, & Hoare. Putnam Hill unit, loc. Mc-2.

1. Left-lateral view of paratype, X3. SUI 40031.

3, 10. Right-lateral (**3**) and left-lateral (**10**) views of paratype, X3. OSU 30733.

4, 12, 14. Right-lateral (**4**), ventral (**12**), and apertural (**14**) views of hypotype, X5. OSU 30739.

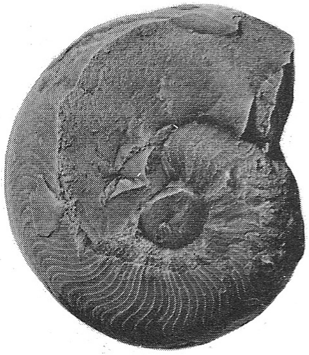
8. Left-lateral view of paratype, X4. OSU 30713.

2, 5, 6, 7, 9. *Neoaganides grahamensis* Plummer & Scott. Views of hypotypes. Brush Creek unit, loc. Ale-18.

2, 6, 7, 9. Apertural (**2**, X13; **6**, X5), left-lateral (**7**, X5), and right-lateral (**9**, X13) views. OSU 30787.

5. Left-lateral view, X5. OSU 30788.

11, 13. *Pennoceras seamani* Miller & Unklesbay. Left-lateral (**11**) and ventral (**13**) views of hypotype, X3. Brush Creek unit, loc. Aa-41; OSU 30707.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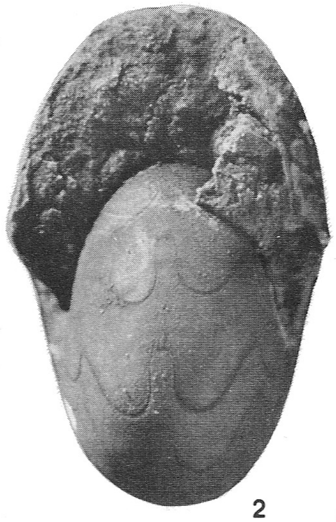
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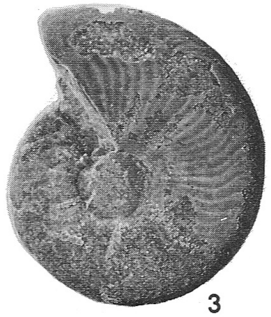
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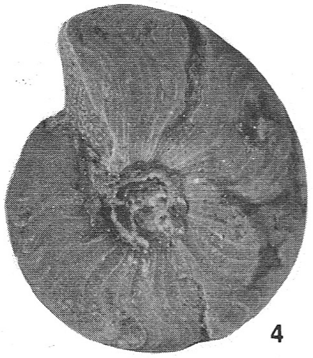
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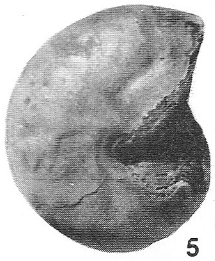
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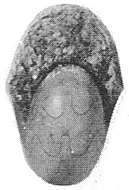
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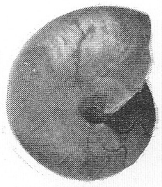
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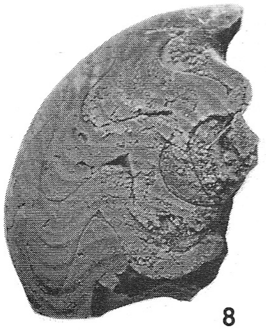
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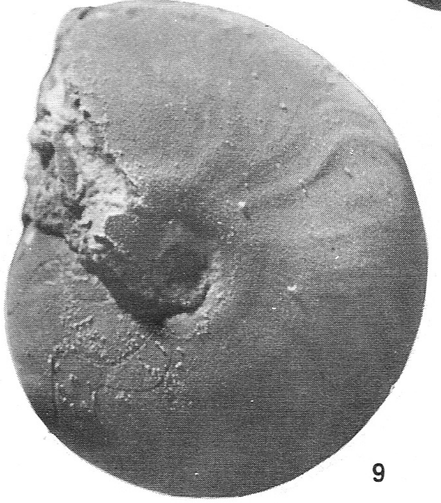
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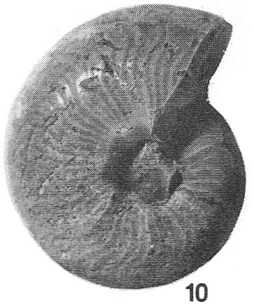
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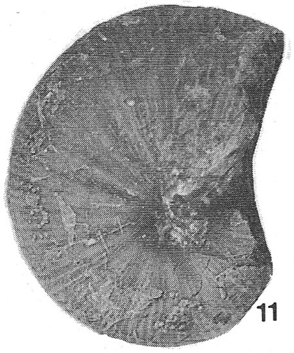
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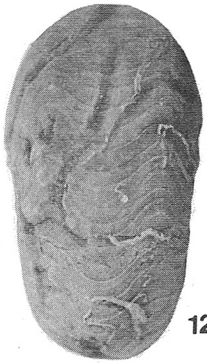
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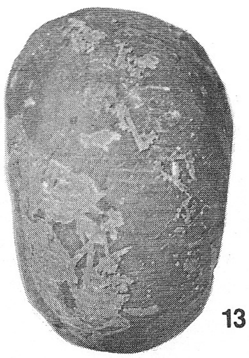
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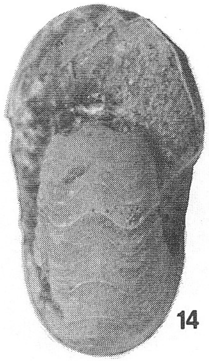
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PLATE 2–1

PLATE 2-2

FIGURE 1. *Gonioloboceras goniolobum* (Meek). Left-lateral view of hypotype, X1. Finis Shale Member of Graham Formation, approximately 3.5 miles (4.6 km) south of Jacksonboro, Texas; SUI 17035.

2. *Gonioloboceras* cf. *G. goniolobum* (Meek). Left-lateral view, X1. Brush Creek unit, loc. Cw-1; OSU 30709.

3, 5-8, 10, 12, 13. *Gonioglyphioceras gracile* (Girty).

3. Left-lateral view of hypotype, X1. Wewoka Formation, unknown location north of Okmulgee, Oklahoma; SUI 47621.

5, 6. Left-lateral (**5**) and apertural (**6**) views of a juvenile paratype, X3. Washingtonville unit, loc. CAr-2; OSU 30711.

7, 10. Right-lateral (**7**) and ventral (**10**) views of holotype, X1. Washingtonville unit, loc. CAr-2; OSU 30712.

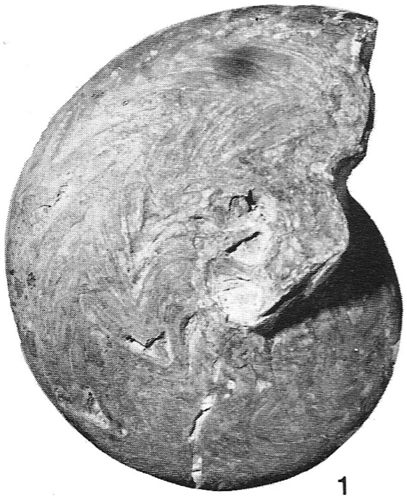
8, 13. Right-lateral (**8**) and apertural (**13**) views of paratype, X3; Washingtonville unit, loc. CAr-2; OSU 48945.

12. Ventral view of paratype showing flattened venter on internal mold, X2. Washingtonville unit, loc. CAr-2; OSU 30797.

4. *Gonioglyphioceras columbianaense* n. sp. Right-lateral view of paratype, X1. Columbiana unit, loc. Cp-3; OSU 18734.

9, 14. *Mangeroceras canfieldense* Sturgeon, Windle, Mapes & Hoare. Left-lateral views of paratypes, X2. Putnam Hill unit, loc. Mc-2; SUI 40034 (**9**) and 40033 (**14**).

11. *Gonioloboceratoides eliasi* (Miller & Owen). Left-lateral view of hypotype, X1. Cherokee beds, southern Iowa; SUI 36318.



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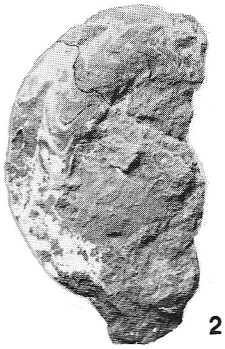

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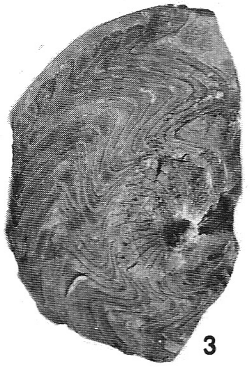

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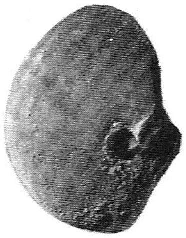

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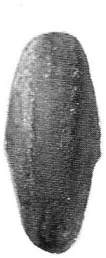

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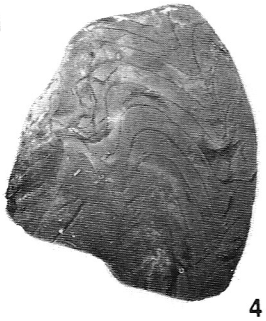

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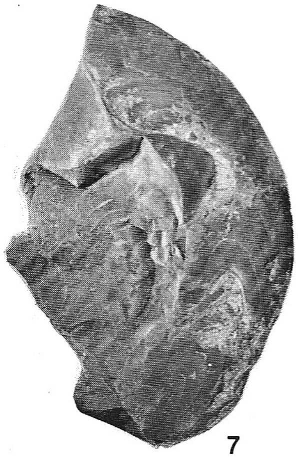

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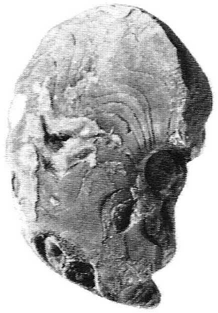

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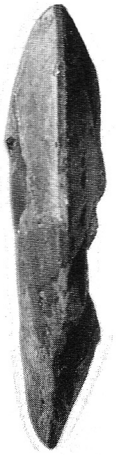

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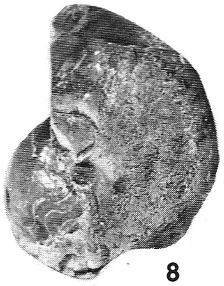

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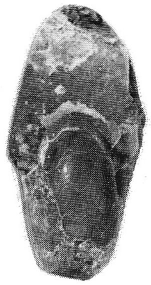

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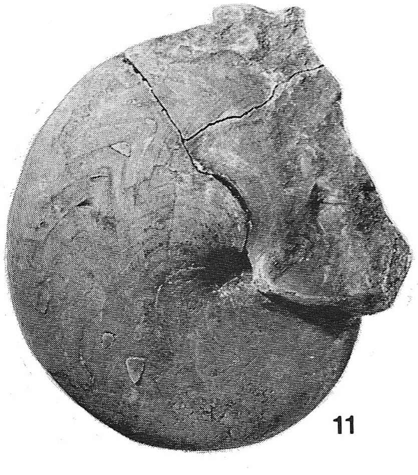

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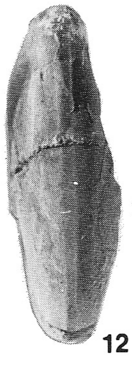

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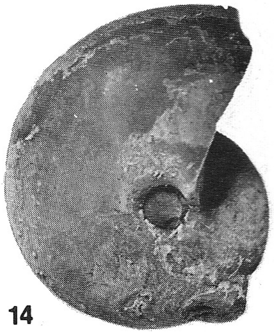

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PLATE 2–2

PLATE 2-3

FIGURES 1-6, 9, 13. *Schistoceras* spp.

1, 3. Ventral (**1**) and right-lateral (**3**) views, X2. Ames unit, loc. MUu-2; OSU 30703.

2, 6, 9. Left-lateral (**2**), right-lateral (**6**), and ventral (**9**) views, X1. Cambridge unit, loc. Ga-1; SUI 1437.

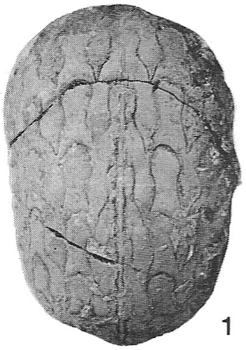
4, 13. Right-lateral (**4**) and ventral (**13**) views, X1. Cambridge unit, loc. Ga-1; SUI 48921.

5. Right-lateral view, X1. Cambridge unit, loc. Gwe-1; OSU 30705.

7, 8, 10-12. *Wellerites* cf. *W. mohri* Plummer & Scott.

7, 10, 11. Right-lateral views before (**7**) and after (**11**) test removal to show suture pattern, and ventral view (**10**), all X1. Columbiana unit, loc. Cs-3; OSU 30726.

8, 12. Left-lateral (**8**) and ventral (**12**) views, X3. Washingtonville unit, loc. CAr-2; OSU 30728.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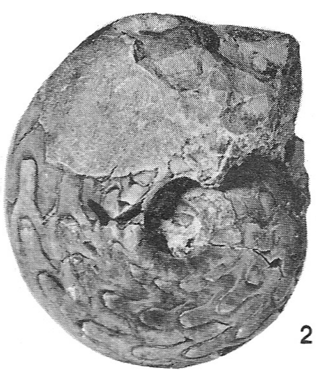
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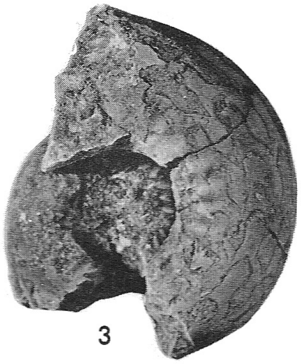
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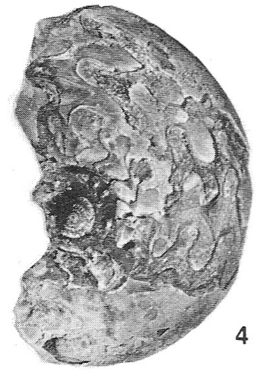
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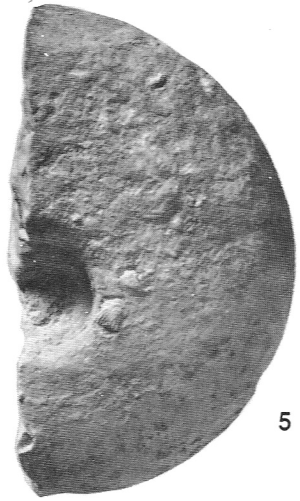
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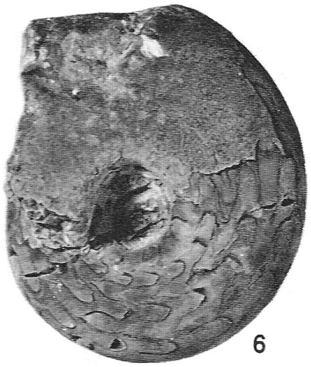
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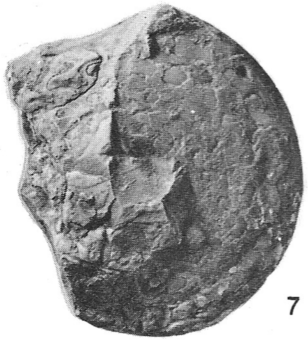
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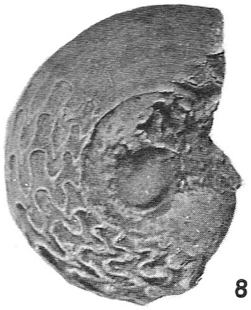
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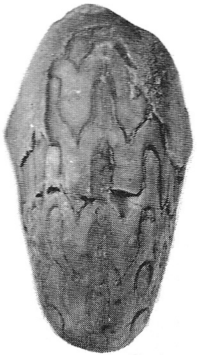
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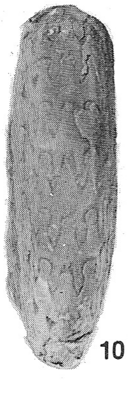
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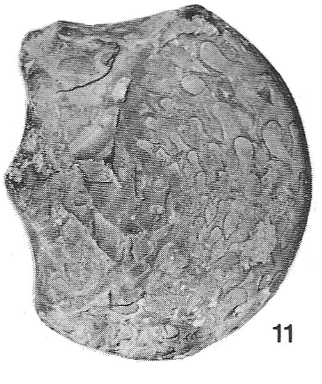
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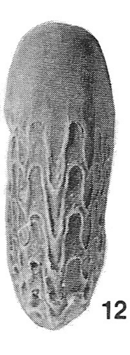
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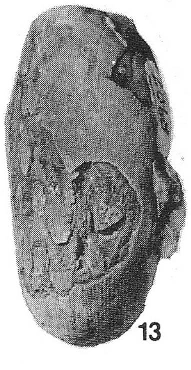
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PLATE 2–3

PLATE 2-4

FIGURE 1. *Eoschistoceras postvenatum* (Plummer & Scott). Right-lateral view of hypotype, X1. Wewoka Formation, Oklahoma; SUI 1962.

2, 6. *Mangeroceras canfieldense* Sturgeon, Windle, Mapes & Hoare. Putnam Hill unit, loc. Mc-2.
- 2. Right-lateral view of holotype, X3. SUI 11050.
- 6. Left-lateral view of paratype, X2. SUI 40026.

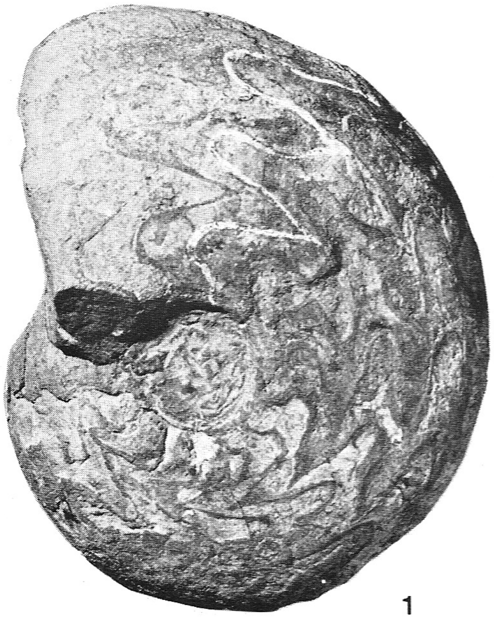
3, 11. *Somoholites saundersi* n. sp. Ventral (**3**) and left-lateral (**11**) views of holotype, X2. Washingtonville unit, loc. CAr-2; OSU 30805.

4. *Dimorphoceratoides campbellae* Furnish & Knapp. Right-lateral view of the single crushed specimen (hypotype) in the Ohio collections, X1.5. Lowellville (Poverty Run) unit, loc. Tfr-1; OSU 30730.

5, 9. *Glaphyrites jonesi* (Miller & Owen). Views of hypotypes, X3. Washingtonville unit, loc. CAr-2.
- 5. Apertural view. OSU 30800.
- 9. Left-lateral view. OSU 48946.

7. *Paralegoceras* sp. Left-lateral view of hypotype, X1. Atoka Formation, Oklahoma; SUI 13998.

8, 10. *Aktubites trifidus* Ruzhencev. Left-lateral (**8**) and ventral views (**10**) of hypotype, X4. Putnam Hill unit, loc. Mc-2; OSU 30723.



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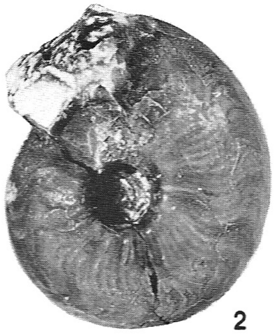

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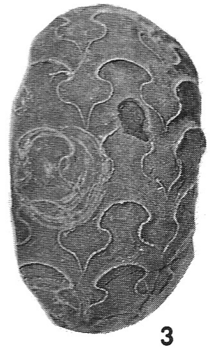

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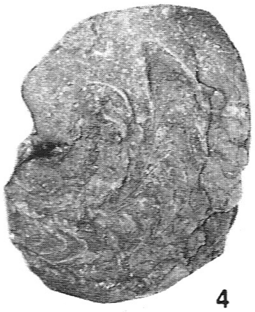

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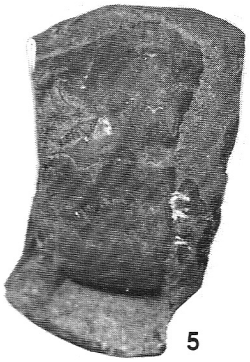

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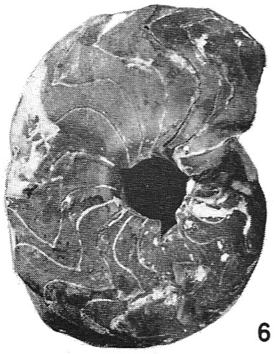

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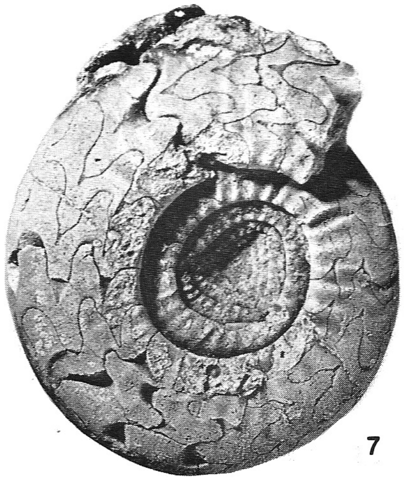

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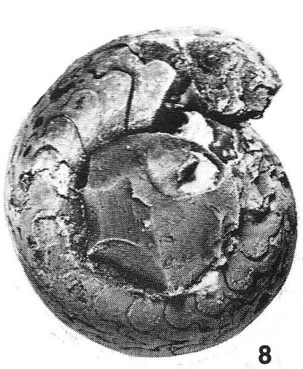

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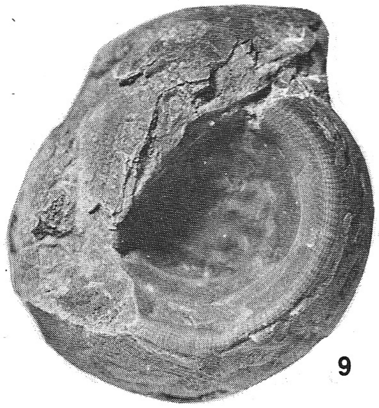

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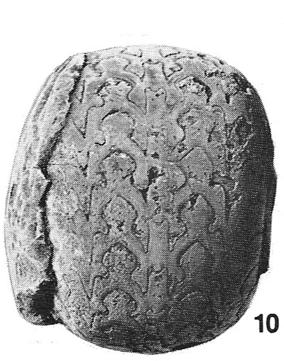

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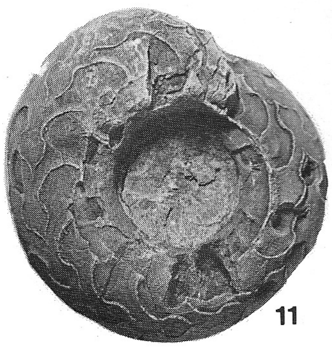

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PLATE 2–4

PLATE 2-5

FIGURE 1. ?*Eoschistoceras* sp. Left-lateral view of the single crushed specimen in the Ohio collections, X1. Putnam Hill unit, loc. Ms-3; OSU 30725.

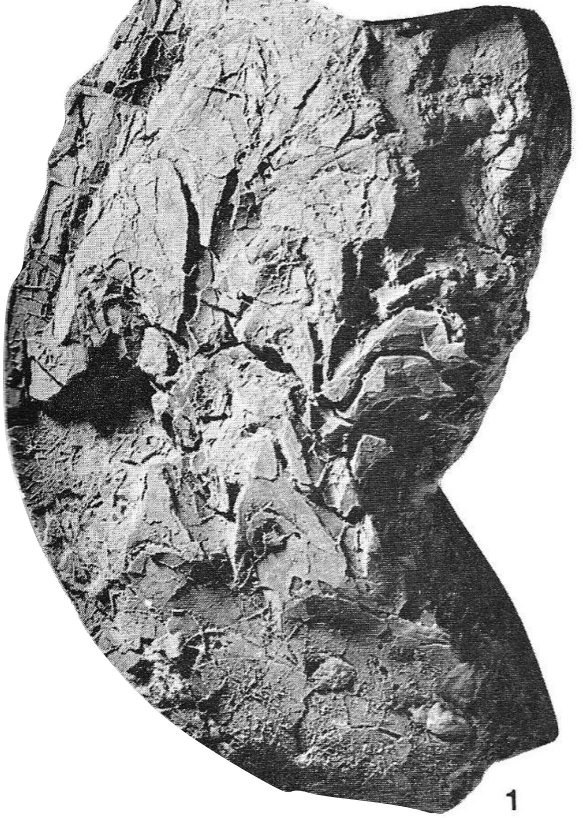
2, 3, 5, 7. *Mangeroceras canfieldense* Sturgeon, Windle, Mapes & Hoare. Views of paratypes. Putnam Hill unit, loc. Mc-2.

- 2. Apertural view, X4. OSU 30733.
- 3, 5. Right-lateral (**3**) and apertural (**5**) views, X3. OSU 30735.
- 7. Right-lateral view, X4. SUI 40034.

4. ?*Paralegoceras* sp. Ventral view of the single poorly preserved specimen in the Ohio collections, X1. Lower Mercer unit, loc. Mbe-1; OSU 30804.

6. *Phaneroceras* cf. *P. compressum* (Hyatt). Right-lateral view of complete but laterally flattened specimen, X1. Lowellville (Poverty Run), loc. Tfr-1; OSU 13327.

8. *Gastrioceras* sp. Ventral view of juvenile specimen, now lost, no data available except that it was collected from the Pennsylvanian of Ohio.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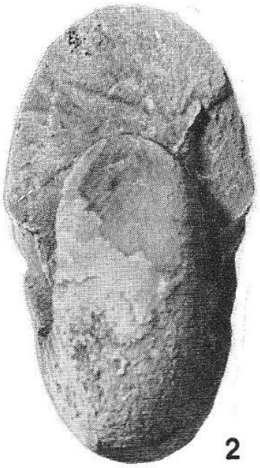
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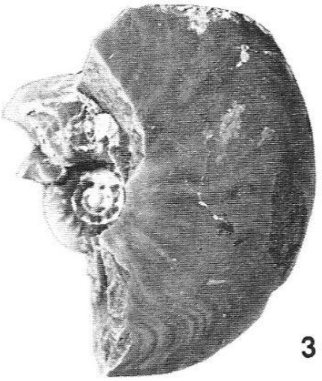
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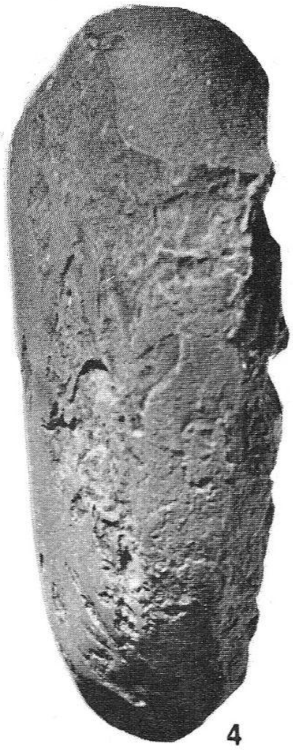
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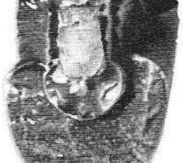
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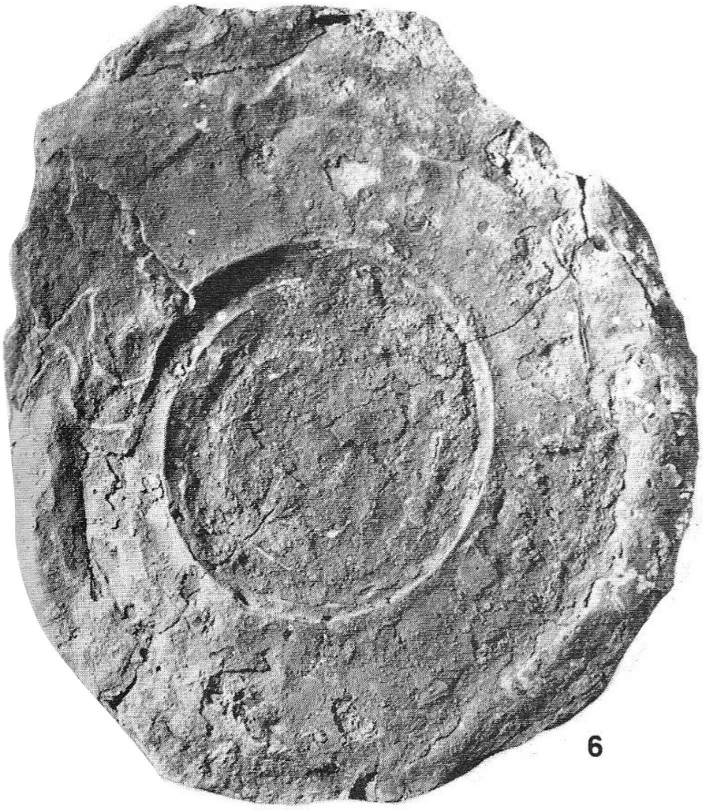
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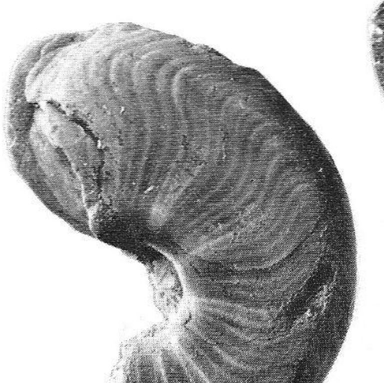
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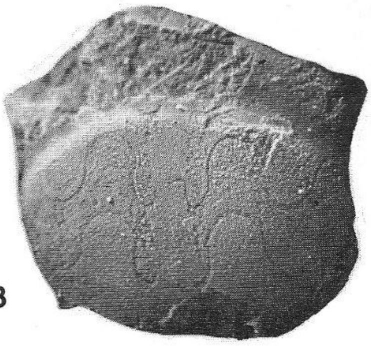
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PLATE 2–5

PLATE 2-6

FIGURES 1-3. *Somoholites sagittarius* Saunders. Right-lateral (**1**), apertural (**2**), and ventral (**3**) views of holotype, X2. Columbiana unit, loc. Cs-7; OSU 18736.

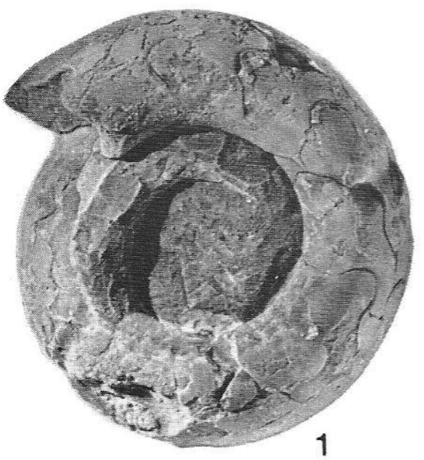
4, 5. *Gastrioceras* sp.

- 4. Ventral view, X3. Putnam Hill unit, loc. Mc-2; OSU 30720.
- 5. Right-lateral view, X1. Lower Mercer unit, loc. MUje-1; OSU 30820.

6, 7. *Paraschistoceras* sp. Left-lateral (**6**) and ventral (**7**) views, X3. Brush Creek unit, loc. Cma-8; OSU 30704.

8-12. *Wellerites* cf. *W. mohri* Plummer & Scott.

- 8, 9. Right-lateral (**8**) and ventral (**9**) views, X2. Putnam Hill unit, loc. Mg-4; OSU 18738.
- 10, 11. Ventral (**10**) and right-lateral (**11**) views, X2. Washingtonville unit, loc. CAr-2; OSU 30731.
- 12. Left-lateral view, X1. Putnam Hill unit, loc. Mc-2; OSU 30729.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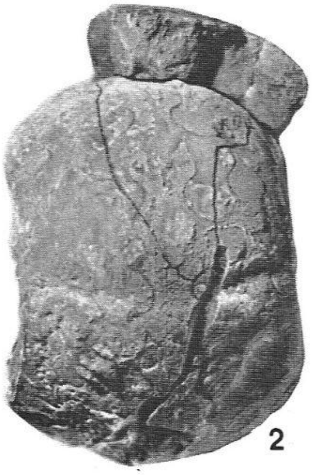
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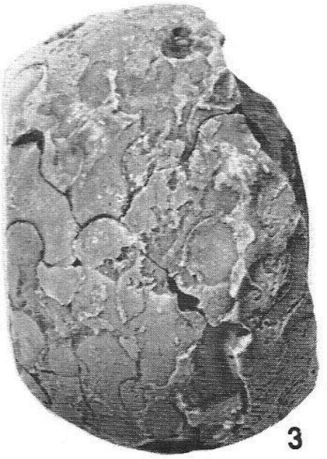
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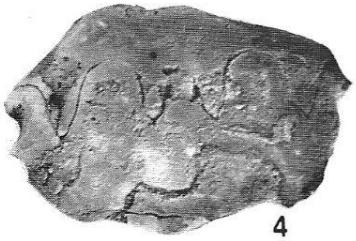
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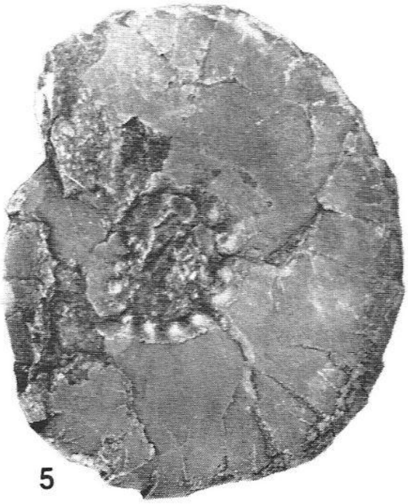
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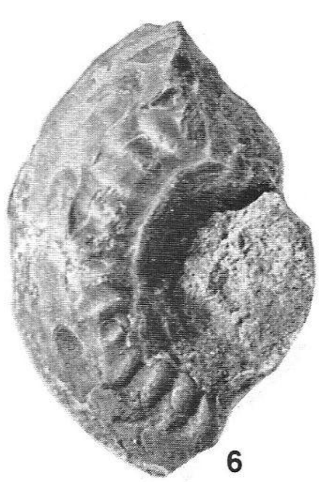
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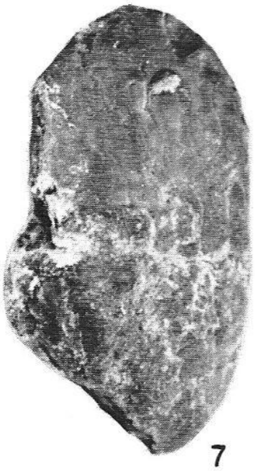
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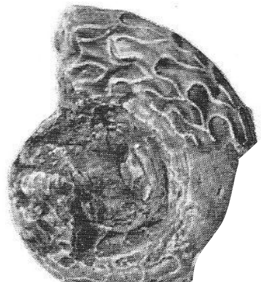
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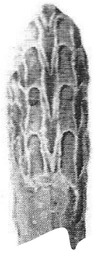
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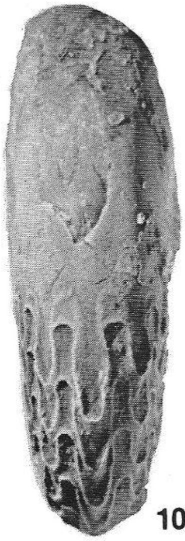
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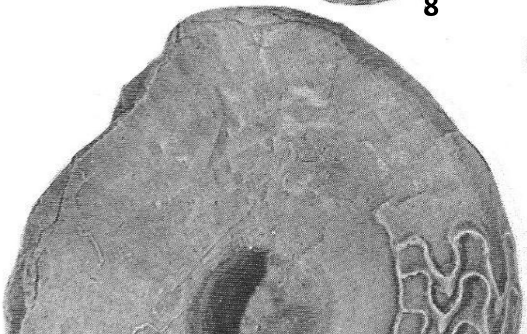
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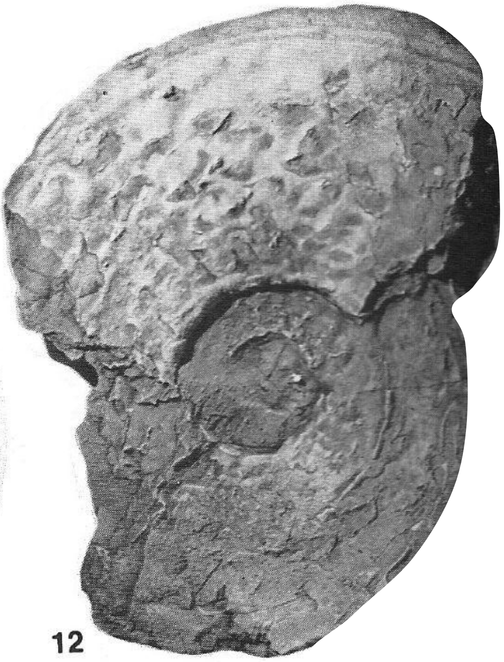
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PLATE 2–6

PLATE 2-7

FIGURE 1. *Gonioglyphioceras columbianaense* n. sp. Left-lateral view of holotype, X1.5. Columbiana unit, loc. Ss-4; OSU 30790.

2-5. ?*Gonioglyphioceras* sp. A. Putnam Hill unit, loc. Mc-2.
  2-4. Right-lateral (**2**), apertural (**3**), and ventral (**4**) views of juvenile specimen, X5. OSU 30792.
  5. Oblique view showing relatively wide, slightly concave venter, X2. OSU 30791.

6. ?*Gonioloboceras* sp. Left-lateral view of juvenile specimen, X5. Portersville unit, loc. Gwe-2; OSU 30823.

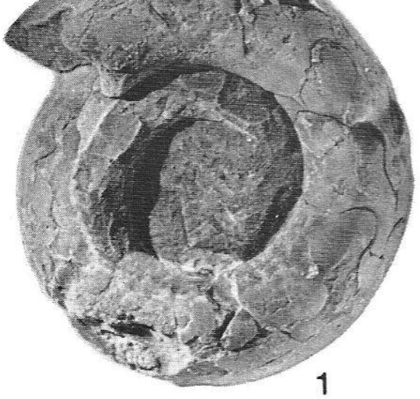
7, 8. *Gonioloboceras* sp. Right-lateral (**7**) and ventral (**8**) views, X1.5. Brush Creek unit, loc. Cfr-1; SUI 11047.

9. Unidentified ammonoid. Ventral view of incomplete specimen, X3. Lower Mercer unit, loc. MUje-1; OSU 30810.

10, 11, 14. *Glaphyrites* cf. *G. anguloumbilicatus* Plummer & Scott.
  10, 11. Right-lateral (**10**) and ventral (**11**) views, X1. Putnam Hill unit, loc. Mc-1; OSU 18735.
  14. Right-lateral view, X1. Washingtonville unit, loc. Tc-1; OSU 30829.

12, 13, 16. *Glaphyrites jonesi* (Miller & Owen). Right-lateral (**12**), left-lateral (**13**), and ventral (**16**) views of topotype, X2. Holdenville Formation, strip pits at Collinsville, Oklahoma; SUI 50969.

15. *Kargalites* sp. Oblique view of internal sutures, X3. Portersville unit, loc. CAc-2; SUI 11046.



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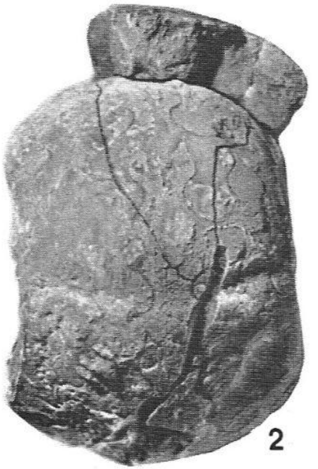

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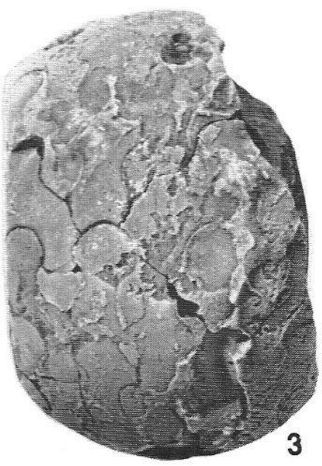

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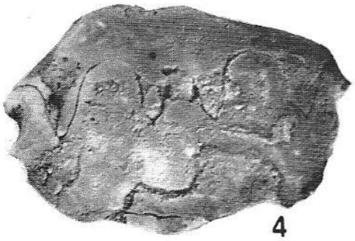

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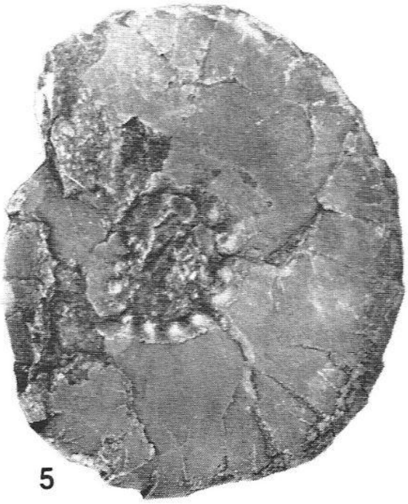

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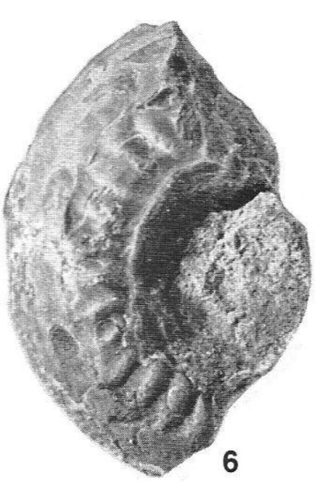

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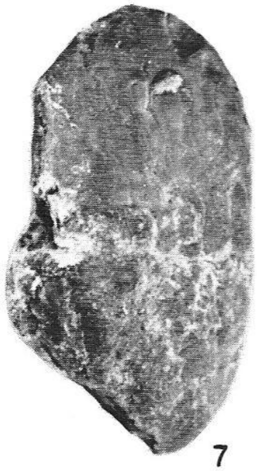

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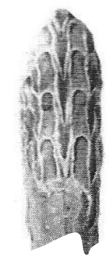

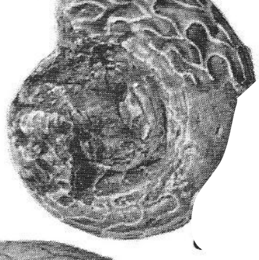

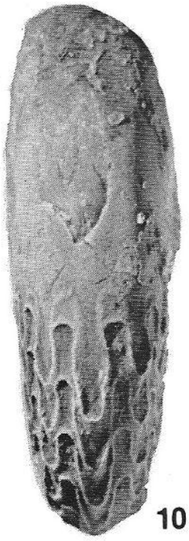

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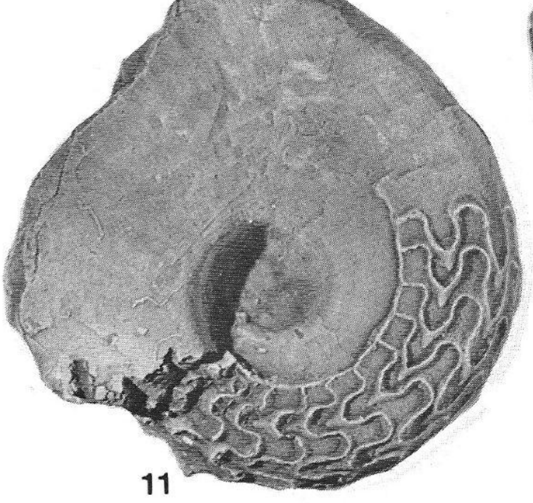

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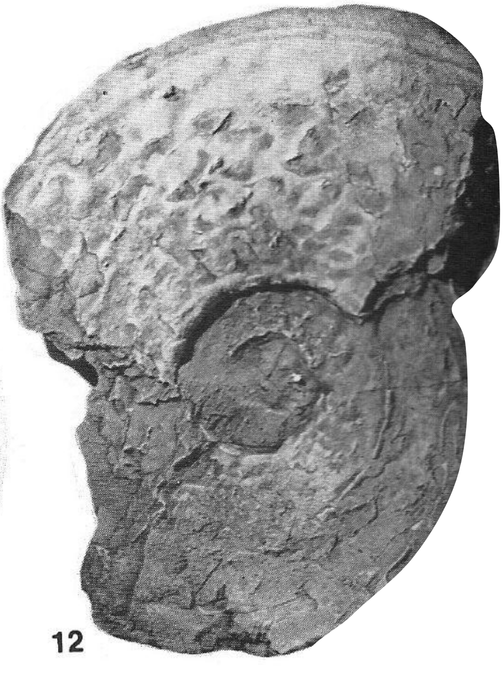

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PLATE 2–7

APPENDIX C.—GLOSSARY OF SOME FEATURES OF CEPHALOPODS AND PERTINENT TERMINOLOGY OF TYPE SPECIMENS

Definitions are modified from Frizzell (1933), Arkell and others (1957), Teichert and others (1964), and Feldmann and Hackathorn (1996). Terms within definitions that are defined in the glossary are in **boldface** type.

achoanitic Describes **septal necks** that are vestigial or absent.

adapertural Situated near or in a direction toward the **aperture**. A synonym is **adoral**.

adapical Pertaining to or situated near **apex** of **conch**.

adnation area (adjective = **adnate**) Area along which **connecting ring** is in contact with **adapertural** surface of free part of **septum**.

adoral Pertaining to or situated near the **aperture**. A synonym is **adapertural**.

adventitious lobe **Lobe** of **suture** formed secondarily by subdivision of **first lateral lobe**.

ammonitic Refers to an ammonoid **suture** in which both the main **lobes** and the main **saddles** are subdivided into smaller lobes and saddles. Also see **ceratitic**, **goniatitic**.

annular lobe Small secondary **dorsal lobe** in center of main dorsal (internal) lobe of **suture** of some coiled forms.

annulation (adjective = **annulate**) Ringlike expansion or ridge on **conch**, either transverse or slightly oblique to **longitudinal** axis of conch.

aperture Opening of **body chamber** of **conch** through which head-foot protrudes.

apex (adjective = **apical**) Initial tip of **conch**.

apicad Toward the **apex**.

aptychus One of a pair of plates found in the **aperture** of some ammonoid cephalopods that, together, are believed to have blocked the aperture when the animal was alive.

auxiliary Refers to **lateral lobe** or **saddle** of **suture** arising from **umbilical lobe** or saddle between second lateral lobe and **umbilical seam**.

beak In an ammonoid cephalopod, part of the mouth apparatus.

bicarinate Having two **carinae** or **keels** on **venter**.

body chamber Anterior portion of **conch** that is not divided by **septa**, adjacent to and open at **aperture** and occupied in life by the animal's body. Also called the living chamber.

brevicone (adjective = **breviconic**) Short and rapidly expanded **conch**.

brim Recurved part of **cyrtochoanitic septal neck**.

caecum Sac-shaped **apical** end of the **siphuncle**.

camera (plural = **camerae**; adjective = **cameral**) Space enclosed between two adjacent **septa** excluding the **siphuncle**.

cameral deposits Calcareous deposits secreted against walls of **camerae** by the animal.

carina (plural = **carinae**, adjective = **carinate**) External continuous sharp ridge along **venter** or **shoulders** of **conch**. Also see **keel**.

ceratitic Refers to an ammonoid **suture** in which the main **lobes** are subdivided into smaller lobes and **saddles**, but the main saddles are not subdivided. Also see **ammonitic**, **goniatitic**.

cicatrix Small groove or scar on **apex** marking former attachment of **protoconch**.

circulus (plural = **circuli**) **Cameral deposit** on concave surface of **cyrtochoanitic septal neck**.

compressed Refers to **conch** or **whorl section** that is higher than wide.

conch (adjective = **conchal**) All hard calcareous parts secreted by cephalopods including external **shell**, **septa**, and **siphuncle** but not **cameral deposits** or any structures within the **siphuncle**. Also see **test**.

conchal furrow Midventral shallow groove on inside of conchal wall.

congener (adjective = **congeneric**) A specimen that is the same genus as another specimen.

connecting ring Porous segment of the **siphuncle** connecting the **septal neck** with the next **septum** immediately behind.

constriction Narrow transverse depression of **conch** marking inward thickening of **test**.

convolute Refers to coiled **conch** in which successive **whorls** partly overlap and envelop preceding whorls. Convolute is intermediate between **evolute** and **involute** but there is no sharp line for the use of these terms for various forms.

costa (plural = **costae**, adjective = **costate**). See **rib**.

cotype A term originally used for either a **syntype** or a **paratype**; term no longer used.

cyrtochoanitic Refers to short **retrochoanitic septal necks** that are curved so as to be concave outward.

cyrtocone, **cyrtoceracone** (adjective = **cyrtoconic**, **cyrtoceraconic**) Mature curved **conch** composed of less than one whorl.

decollation Natural loss during life of **apical** portion of **conch** (**phragmocone**). A synonym is truncation.

depressed Refers to **conch** or **whorl section** that is wider than high.

dorsad Toward the **dorsum**.

dorsal lobe Median primary **lobe** of **suture** on **dorsum** (internal in normally coiled **conchs**).

dorsum (adjective = **dorsal**) Top of a cephalopod and its **conch**; in slightly **involute shells** equivalent to **impressed area**, but in deeply involute shells refers only to portion of conch adjacent to **venter** of preceding **whorl**. Opposite term is venter.

ectosiphuncular Refers to **siphuncular deposits** located outside the **siphuncle**. Also see **cameral deposits**.

endosiphuncular Refers to **siphuncular deposits** located within the **siphuncle**.

episeptal deposits **Cameral deposits** on concave (**orad**) side of **septum**.

evolute Refers to coiled **conchs** in which the **whorls** are in contact with one another but have little or no overlap and all whorls are exposed in lateral view; consequently **umbilicus** is wide. Also see **convolute**, **involute**. Evolute, convolute, and involute are relative terms and there is no sharp line in their use for various forms.

external suture The part of the **suture** of coiled **conchs** that is visible on outside of **whorls** between **umbilical seams**.

first lateral lobe First primary **adapical** inflection of **suture** next to external or **ventral lobe**.

flank Side of **conch** between **venter** and **dorsum**.

flared Refers to **aperture** of constricted **body chamber** that has an apertural diameter greater than diameter of inflated portion of body chamber.

goniatitic Refers to an ammonoid **suture** in which neither the **lobes** nor the **saddles** are subdivided into smaller lobes and saddles. Also see **ammonitic**, **ceratitic**.

growth lines Fine, small to minute, parallel, **transverse**, raised lines or ridges separated by similar grooves or channels on **conchal** surfaces marking repeated minor halts in growth and former positions of the **aperture**.

gyrocone, gyroceracone (adjectives = **gyroconic**, **gyroceraconic**) Loosely coiled mature **conch** in which successive **whorls** are not in contact with each other.

holochoanitic Refers to **retrochoanitic septal necks** that extend backward through length of one **camera**.

holotype The single specimen on which a new species or subspecies is based.

homeotype A specimen that has been carefully compared with and identified with an original or primary type.

hyponome A muscular tube through which a cephalopod directs water when swimming by "jet propulsion"; it is **ventral** in position.

hyponomic sinus A large **ventral** concave structure in the middle of the **aperture** that is expressed in the **growth lines**; it marks the position of the **hyponome**; ventral position of hyponomic sinus is useful in determining orientation of **conchs**.

hyposeptal deposits **Cameral deposits** on convex (**adapical**) side of **septum**.

hypotype A specimen not used in the original description of a species or subspecies but used for a later description or figure of it, to extend or correct knowledge of the taxon.

impressed zone Concave **dorsum** in coiled **conchs**, in contact with **venter** of preceding **whorl** and lying between **umbilical seams**. Also called the **impressed area**.

infundibulum An **umbilical** depression that has a conical shape.

internal suture In coiled **conchs**, the part of **suture** on **dorsum**, lying between **umbilical seams**, and concealed unless conch is broken.

involute Refers to tightly coiled **conchs** in which **whorls** strongly overlap so that last whorl envelopes and covers preceding whorls; consequently, **umbilicus** is narrow. Also see **convolute**, **evolute**. Involute, convolute, and evolute are relative terms and there is no sharp line in their use for various forms.

keel External, continuous, distinct, solid or hollow **longitudinal** ridge on **venter**. Also see **carina**.

lanceolate Spear shaped; refers to form of **suture**, **lobes**, or cross section of acute periphery of **shell**.

lappet Simple or necked projection of the **peristome** on **whorl** sides or **venter**.

lateral lobe Any primary **adapical** inflection of **suture** between **ventral** and **dorsal lobes**; **first lateral lobe** is next to **ventral saddle**, generally on **whorl** side but in **depressed** whorls commonly on **venter**, second lateral lobe is next to **first lateral saddle**, commonly on whorl side and part of **umbilical lobe**.

lateral saddle Any primary **orad** inflection of **suture** separating **lateral lobes** from each other or from external or internal lobes. First lateral saddle separates **ventral lobe** from **first lateral lobe**; second lateral saddle, commonly called first lateral saddle, separates first and second lateral lobes.

lectotype A type specimen chosen after the original description to take the place of the **holotype**.

lirae (singular = **lira**; adjective = **lirate**) Fine, parallel, t**ransverse** or **longitudinal** raised lines or ridges separated by **striae** on surface of **conch**.

living chamber See **body chamber**.

lobe Undulation of **suture** that points away from **aperture**; reverse of **saddle**.

longitudinal Refers to a structure that is parallel to length of **shell**; generally equivalent to spiral.

loxochoanitic Describes short, straight **septal necks** that point obliquely toward interior of **siphuncle**.

mural deposits **Cameral deposits** along parts of **septa** attached to wall of **conch**.

nautilicone (adjective = **nautiliconic**) Strongly **involute** coiled nautiloid **conch**.

neotype A specimen selected to take the place of an original type specimen when the **holotype** and all **paratypes** have been lost or destroyed.

nepionic constriction A narrowing in **conch** diameter in the early stage of ontogenetic growth. In *Nautilus* this constriction at a diameter of about 25 mm is considered to mark the time of hatching.

ocular sinus A paired set of small shallow **sinuses** on lateral sides of the **aperture** in the position of the eyes of *Nautilus*.

orad Toward the **aperture**.

orthochoanitic Describes **retrochoanitic septal necks** that are straight cylindrical and extend only a short way toward the preceding **septum**.

orthocone, **orthoceracone** (adjective = **orthoconic**, **orthoceraconic**) Mature straight **conch**.

paratype(s) A specimen or specimens used in addition to the **holotype** in preparing the original description of a new species or subspecies for which a holotype is designated.

peristome Edge of **aperture** of **body chamber**.

phragmocone portion of **conch** that is divided by **septa**.

prong **Apicad** projection of **ventral lobe** in typical **goniatitic suture**; prongs are separated by **secondary ventral saddle**.

protoconch First chamber of **shell**; also called initial chamber or apical chamber.

radial See **transverse**.

reniform Kidney shaped.

reticulate Having a netlike or meshlike pattern; a reticulate pattern commonly is formed by the intersection of **growth lines** and linear **ornament** such as ribs or **lirae**.

retrochoanitic Refers to a **septal neck** that is directed backward toward **apex**.

retuse Refers to **venter** that is rounded or obtuse and has a slight revolving notch separating two narrow **carinae**.

rib Radial raised ridge on coiled **conch**. A synonym is **costa**.

saddle Undulation of **suture** that points toward **aperture**; reverse of **lobe**.

sensu "In the meaning of," in reference to application of the name of a taxon.

sensu lato "In a broad sense," in reference to wide application of the name of a taxon.

septal foramen (plural = **septal foramina**) Opening in **septum** for passage of **siphuncular cord**. Also called siphuncular foramen.

septal neck Portion of **septum** bent **adapically** or backward around **septal foramen**.

septum (plural = **septa**) Transverse partition dividing **phragmocone** into chambers (**camerae**) and attached to inside of **conchal** wall.

septum of truncation Transverse partition of **conch** consisting of specialized thick **septum** forming base of mature **shell** in groups that shed juvenile **phragmocone**.

shell Complete hard parts including **protoconch** and **conch** but excluding ammonoid **aptychus** and **beaks** or jaw structures and nautiloid **cameral** and **siphuncular deposits.** Also see **conch, test**.

shoulder Blunt angle of **whorl**, may be **ventrolateral** or **umbilical** in position.

sigmoidal Refers to an object that is S shaped, sinuous, or flexuous.

sinus Any part of a **transverse** feature such as **apertural** margin, **ribs**, **growth lines**, etc. that is concave toward aperture.

siphuncle Long tube extending through all **camerae** to **apex** and consisting of soft and shelly parts including **septal necks**, **connecting rings**, calcareous deposits, and **siphuncular cord** (siphon).

siphuncular cord Fleshy interior tissues of **siphuncle**. A synonym is siphon.

siphuncular deposits Calcareous deposits secreted within the **siphuncle**, especially near **apex** of **shell**. Also called siphonal deposits.

siphuncular foramen See **septal foramen**.

siphuncular segment Any part of **siphuncle** between two successive **septal foramina**.

striae (adjective = **striate**) Small to minute parallel **transverse** or l**ongitudinal** grooves or channels separated by **lirae** on **conchal** surface.

sulcus Groove on **conchal** surface, generally referring to **longitudinal** groove on **venter**.

sutural elements Major undulations of **sutures** alternately directed forward toward **aperture** as **saddles** and backward toward **apex** as **lobes**.

suture Line of junction of free part of **septum** and inner **phragmocone** wall.

syntype A specimen or specimens on which a new species or subspecies is based when no **holotype** has been designated.

tarphycone, **tarphyceracone** (adjectives = **tarphyconic**, **tarphyceraconic**) Mature, very **evolute**, coiled **conch** having many **whorls** and little overlap of whorls.

test External **shell** material, regardless of form or shape.

testiferous Bearing external **shell** material.

topotype A specimen collected from same unit and same locality as **holotype** or **syntypes**.

truncation See **decollation**.

transverse In a direction outward from center of **umbilicus** at right angles to axis of coiling and growth. A synonym is **radial**.

type species The species on which the original description of a new genus is based.

umbilical angle Same as **umbilical shoulder** but angular.

umbilical area Inner part of **whorl** on each side adjacent to axis of coiling, separating **umbilical angle** from **umbilical seam**; called umbilical wall if it rises somewhat vertically from spiral plane and umbilical slope if it rises gently.

umbilical diameter Width of **umbilicus** measured between either **umbilical shoulders** (Umax) or **umbilical seams** (inside diameter, Umin).

umbilical lobe Large primary lobe of ammonoid **suture** centered on or near **umbilical seam** and forming part of both external and internal sutures.

umbilical perforation Empty space around axis of coiling, connecting **umbilicus** on opposite sides of **conch**.

umbilical seam or **suture** Helical (spiral) line of junction of adjacent **whorls** of coiled **conchs**.

umbilical shoulder Strongly bent portion of **whorl** surface between **flank** and **umbilical wall** or slope. Also see **umbilical angle**.

umbilical wall See **umbilical area**.

umbilicus (adjective = **umbilical**) External depression around axis of coiling near center of **whorls** of coiled **conchs** within the **umbilical angle**.

venter (adjective = **ventral**) In a coiled **conch**, the part of **whorl** farthest from axis of coiling; in an **orthocone**, the underside or bottom of conch.

ventrad Toward the **venter**.

ventral lobe Main **adapical** inflection of suture on **venter**; external in normally coiled **shells** and thus referred to as external lobe.

ventral saddle In nautiloids, main **orad** inflection of **suture** on **venter**; in ammonoids, median saddle of suture on venter, external in normally coiled shells and thus referred to as external saddle.

ventrolateral shoulder or **angle** Angle between **venter** and **flank** of coiled **conch**.

ventromyarian Refers to a nautiloid cephalopod in which the retractor muscles of head-foot are attached to **shell** along areas of interior of **body chamber** adjacent to or coincident with its midventral line.

volution See **whorl**.

whorl One complete turn of coiled **conch**. Also called a volution.

whorl height Height of **whorl** measured at right angles to maximum width, consisting of distance from middle of **venter** to middle of **dorsum** plus depth of **impressed area**; in practice, oblique whorl height commonly is used, consisting of distance from **umbilical seam** to middle of venter.

whorl section Cross section or transverse section of **whorl**.

whorl width Maximum horizontal distance between points located between **ribs or spines on opposite whorl sides.**

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PENNSYLVANIAN CEPHALOPODS OF OHIO

Pt. 1, Nautiloids and bactritoids: Sturgeon, Windle, Mapes, and Hoare
Pt. 2, Ammonoids: Mapes, Windle, Sturgeon, and Hoare

1997